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School of Land and Food

Strategic nutritional enhancement of cow-calf performance in South Central Coastal Vietnam

By

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Declaration of Originality

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The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

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Abstract

The increasing demand for beef in Vietnam has opened up great opportunities for farmers to improve their income base. However, some deficiencies in animal nutrition and management need to be addressed before these opportunities are captured. Therefore, the aim of this thesis was to improve the productivity of the cow-calf system in the South Central Coastal (SCC) area of Vietnam through: i) identifying the characteristics and management practices in Nhon Khanh commune; and ii) determining the impact of supplementing cows with concentrate 3 months pre- and post-partum on liveweight (LW), body condition score (BCS) and calving to conception interval (CCI).

Structured interviews of 103 smallholder farmers, who owned from 1 to 4 cows, were utilised to characterise management practices of the cow-calf production system, coupled with an evaluation of BCS and reproductive performance of 475 cows in Nhon Khanh from January to July 2014. In addition, 165 calves (0-6 months old) were weighed and body length and chest girth measured monthly to assess growth rate. Baseline results from this characterisation phase of the study indicated that feed shortage was considered by farmers to be the biggest constraint to cow-calf production in Nhon Khanh commune, as evidenced by over-grazing. Approximately 50-70% of households faced pronounced feed shortages, particularly in December and January. Cow body condition score was negatively correlated with CI and daily duration of grazing - cows spending more time grazing had lower BCS and longer CI compared to cows grazing for shorter periods. Subjective visual assessment of the physical body conformation of calves was adjudged to be the major determinant of sale price. Nearly all surveyed farmers fed concentrates, e.g., maize, rice bran, and cassava powder, and cooking was the most common method of preparing the concentrate. In order to improve the efficiency of use of the traditionally cooked concentrate, and to boost pre- and post-partum cow performance, an experimental phase utilising improved supplementary diets from local feed resources was the next logical step of the study.

Twenty crossbred cows (initial average LW of 366 ± 53 kg and parity ≤5) in their third trimester of pregnancy were randomly allocated into one of four pre- and post-

partum supplementation regimens: 1) Control diet only; 2) Control diet pre-partum and improved diet post-partum; 3) Improved diet pre-partum and control diet post-partum; and 4) Improved diets pre- and post-partum. The control diet was a mixture of maize powder and rice bran offered at 0.25% of body weight (BW) pre-partum (90 days) and 0.35% of BW post-partum (90 days). The improved diet was a mixture of maize powder (20%), rice bran (20%), peanut cake (20%) and cassava meal (39%) offered at 0.35% of BW pre-partum and 0.5% of BW post-partum. All treatment groups were fed a basal diet of 30% King grass and 70% rice straw of DM at 2% of their bodyweight. Feeding of the improved diet had a significant ($P<0.05$) positive effect on calf LW, body length and chest girth at birth, but not at 90 days of age. There was a significant effect of diet on the average cow BW ($P<0.01$), BCS ($P<0.01$) and CCI ($P<0.0001$). However, there was insufficient evidence for the effect of the timing of feeding the concentrate (pre- or post-partum) on cow LW, BCS and cow fertility.The CCI was longer for cows fed the control diet (212 days) than for cows fed the improved diet pre-partum (176 days). Cows fed the improved diet post-partum had the shortest CCI (144.5 days). Post-partum supplementation improved cow-calf performance and induced early cyclicity, thereby shortening CCI and enhancing overall reproductive performance under on-farm conditions.

There are several implications of this research for beef production in Vietnam. Firstly, from the surveys, it found out some problems of cow-calf system in Vietnam such as inadequate feeding, especially in feed shortages period, poor grazing management, and lack of calf management. Secondly, this research pointed out that the efficient of cow-calf system can be increased if the cow-calf management and feeding system are improved. In addition, cow's BCS and reproductive performance could be improved by using improved diet post-partum for cows.

In conclusion, the combined results from this study demonstrated the opportunity for smallholder farmers to increase the productivity of their cow-calf system through strategic supplementation with improved diets to mitigate against seasonal feed shortages and over-grazing of crowded communal land.

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List of abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADF	Acid detergent fibre
AI	Artificial insemination
AOAC	Association of Official Analytical Chemist International
Ash	Mineral
AUD	Australia dollar
BCS	Body condition score
BW	Body weight
CCI	Calving to conception interval
CFSI	Calving to first service interval
CI	Calving interval
CP	Crude protein
CRFS	Conception rate at first service
DARD	Department of Agriculture and Rural Development
DM	Dry matter
EE	Ether extract
GSO	General Statistics Office
HH	Households
LS	Least square
LSM	Least square means
LW	Liveweight
NDF	Neutral detergent fibre
NRC	National Research Council
PR	Pregnancy rate
SCC	South Central Coastal
SE	Standard error
VND	Vietnam Dong

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Chapter 1 General introduction

Improving cattle production in rural areas of developing countries is an efficient way to reduce poverty (Kristjanson et al., 2010). In Vietnam, 70% of livestock are raised by smallholder farmers (GSO, 2014).The integrated crop-livestock farming system, in which livestock and crops are produced within a coordinated framework (Van Keulen and Schiere, 2004) is the most common operation. The recent increase in the sale price of beef cattle has raised considerable interest among smallholder farmers to switch from an extensive, pasture-based system to an intensive stall feeding production system. Intensive production systems require higher inputs of capital, labour and knowledge to realise the high income potential. A cow-calf system is a method of raising beef cattle in which a permanent herd of cows is kept by farmers to produce calves for sale (Womach, 1997). The success of this system depends largely on the reproductive efficiency of cows, i.e., how quickly a cow returns to oestrus, the number of services required before conception, and how quickly a calf attains market weight. These goals are accomplished through sound nutrition, health and breeding management.

A typical diet of cattle in the South Central Coastal (SCC) area of Vietnam consists of native grass, cultivated forages and crop by-products, particularly rice straw (Ba et al., 2005). In addition, the roughage resources available are dependent on prevailing seasonal and weather fluctuations. Limited nutrition and poor management practices can lead to a long CI and low growth rates. This can lead to a lower number of heifer calves for herd replacement as well as a lower number of calves sold. Improving the efficiency of the integrated crop and livestock system can ensure improved animal output, thus increasing the profitability. However, there remain some constraints and obstacles that create major challenges to the cow-calf production system in Vietnam, particularly feed availability and quality. In order to improve the cow-calf system, it is essential to undertake a comprehensive assessment to identify its strengths and weaknesses. Once identified, new technologies and management skills can be introduced to assist in improving productivity and profitability for farmers and ensuring beef supply meets the demand in Vietnam.

Matching the basic nutritional requirements is a key factor to achieving profitability goals in cow-calf production system (Hersom, 2010). It is necessary that cows have access to adequate and good quality feed that supplies nutrients capable of meeting requirements for lactation and reproduction as well as calf health and growth. Higher energy and protein levels are required for maintenance and development of the growing foetus during pregnancy (NRC, 2000). Protein requirement only becomes much more significant in the last trimester of pregnancy (Moran, 2005). Energy stored during the last trimester of pregnancy, calving and early lactation affects the length of post-partum anoestrus interval and the probability of successful conception (Chagas et al., 2007). Poor nutrition during late pregnancy can increase the CI(Ferrell, 1991; Short et al., 1990), lower milk production and decrease calf weight at weaning (Bellows and Short, 1978; Corah et al., 1975). In addition, inadequate nutrition of cows in the last trimester of pregnancy might cause death in-utero or reduce viability at birth (McDonald, 2002). In summary, inadequate nutrients over a long period can result in low cow fertility, poor reproductive performance, and poor body condition of calves.

Concentrate-based supplements are used in cow-calf production systems in order to correct nutritional deficiencies and ensure balanced diets. Supplements with high protein contents can help Zebu cattle improve their reproductive efficiency (Robinson, 1990). In a study by Galina and Arthur (1989), cow reproductive performance was improved by supplementing 8 weeks before calving to 8 weeks after calving. In contrast, Soto et al. (2001) found that pregnancy rate was not improved by the level of supplementation offered before and/or after calving.

Body condition score (BCS) is used as a subjective measure of the body fat reserves of sheep, beef, and dairy cattle (Lowman et al., 1973). It is an accepted, quick and cheap method of gauging the nutritional status of cattle (Popescu et al., 2009a; Waltner et al., 1993b). Several studies on dairy cows have been undertaken on the relationship between BCS and fertility (Gillund et al., 2001a; Roche et al., 2007), but the results are conflicting. Some studies concluded that there is apositive relationship between reproduction and pre-partum body condition (Mouffok et al., 2013; Singh et al., 2009) and post-partum

body condition (Patton et al., 2007), while others reported that body condition only affects milk production (Walter, 1993).

In Vietnam, most of the ruminant nutrition studies have focused on beef bulls or dairy cows and very little has been done on beef cows. There is a dearth of information about the effect of supplementing beef cows during the pre- and post-partum periods on cow-calf performance under on-farm management conditions in Vietnam.

While there is a general understanding of current livestock production systems in the published literature, in particular beef finishing, there is a paucity of knowledge relating to the cow-calf production system. A number of research questions relating to the characteristics of the cow-calf production system and concentrate supplementation of crossbred beef cows are raised to be answered in this thesis:

1. What is the characteristics of the current cow-calf production system in SCC Vietnam, and what are the strengths and weaknesses of this system?
2. How does concentrate supplementation pre- and post-partum affect cow LW, BCS, and fertility performance?
3. How does concentrate supplementation pre- and post-partum affect calf growth performance at birth and at 90 days of age?
4. When is the best phase (pre- and/or post-partum) of supplementation to improve profitability?

Accordingly, the objectives of this thesis were:

1. To assess the cow-calf production system in Nhon Khanh commune to understand the current animal, feed and health management practices and to highlight the directions and strategies for further cow-calf research and development in SCC Vietnam. This is explored in Chapter 3.
2. To evaluate the impact of concentrate supplementation 3 months pre- and post-partum, on cow-calf productivity in SCC Vietnam. This is investigated in Chapter 4. The hypotheses tested were:
    i) Adequate cow nutrition in the last 3 months of pre-partum gestation will improve cow BCS and liveweight (LW),

ii) Adequate cow nutrition in the last 3 months pre-partum will increase the LW of newborn calves, and

iii) Adequate cow nutrition in the 3 months either pre-partum or post-partum can improve cow reproductive performance and reduce the CI.

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Chapter 2 Literature review

In this review the characteristics of beef cattle management, with a specific focus on the cow-calf production system in South Central Coastal Vietnam are investigated. Factors influencing cow reproductive performance, nutrient requirements of cows and calves and the interaction between nutrition and fertility on the growth performance of calves are also discussed. Identified knowledge gaps in the published literature are highlighted and opportunities for research in improving the management of cow reproduction and fertility in South Central Coastal of Vietnam are outlined and discussed.

2.1 Agricultural production in Vietnam

The economy of Vietnam is largely dependent on agriculture and 68% of the 90 million Vietnamese live in rural areas, with 47% of the population aged 15 years and above working directly in the agricultural sector (GSO, 2014). Integrated rice and livestock production is the most common agricultural production system in Vietnam. The production of paddy rice has sharply increased and led to increased rice exports from 1990-2014(Thanh and Singh, 2006). At present, Vietnam is the third largest rice exporter in the world. Total rice exports rose from approximately 5.2 million t in 2005 to 6 million t in 2014 (GSO, 2014).

One billion people around the world depend on livestock for their livelihood (McDermott et al., 2010). In addition, livestock plays a crucial role in ameliorating poverty in developing countries (Kristjanson et al., 2010). Livestock production plays an important role in Vietnam's agricultural systems as it contributes 26 % of total annual agriculture products (GSO, 2014). Smallholder farmers account for 70 % of the total livestock production and are important contributors to household income in the rural areas of Vietnam (GSO, 2014). In addition, livestock is also important for providing protein to Vietnamese residing in the rural areas.

Vietnam is the sixth largest producer of pork in the world (Meyer and Steiner, 2010). In 2014, Vietnam produced approximately 3.33 million metric t of pork (GSO, 2014), of

which 30% was produced by smallholder farms (Lumb, 2011). Poultry comes second after pig production. In 2005, 7.9 million Vietnamese kept poultry, with 92% of them raising less than 50 head of chickens (FAO, 2008).

Traditionally, Vietnamese raise cattle for generating income, utilising agricultural by-products and native grass, and producing meat, draught power and manure (Phung and Koops, 2003). Labour input into this system is high, and feed resources come in the form of pasture, and crop residues that are cut and are carried to the cattle pens. The profitability of this system is minimal because of the low growth rate of local cattle.

Over the past 20 years, the annual economic growth rate in Vietnam has been 7-8% annually. The annual human population growth rate was 1.05% per year from 2010 to 2014 (GSO, 2014). Due to economic development resulting in improvements in household income and better living conditions, the demand for a greater diversity of foodstuff, in particular, meat and dairy products, is increasing.A similar trend in livestock products consumption in Mekong countries: Cambodia, Lao People's Democratic Republic (PDR), Thailand and Vietnam is shown in Figure 2.1. In general, consumption of livestock products has increased quickly, especially in Thailand and Vietnam.

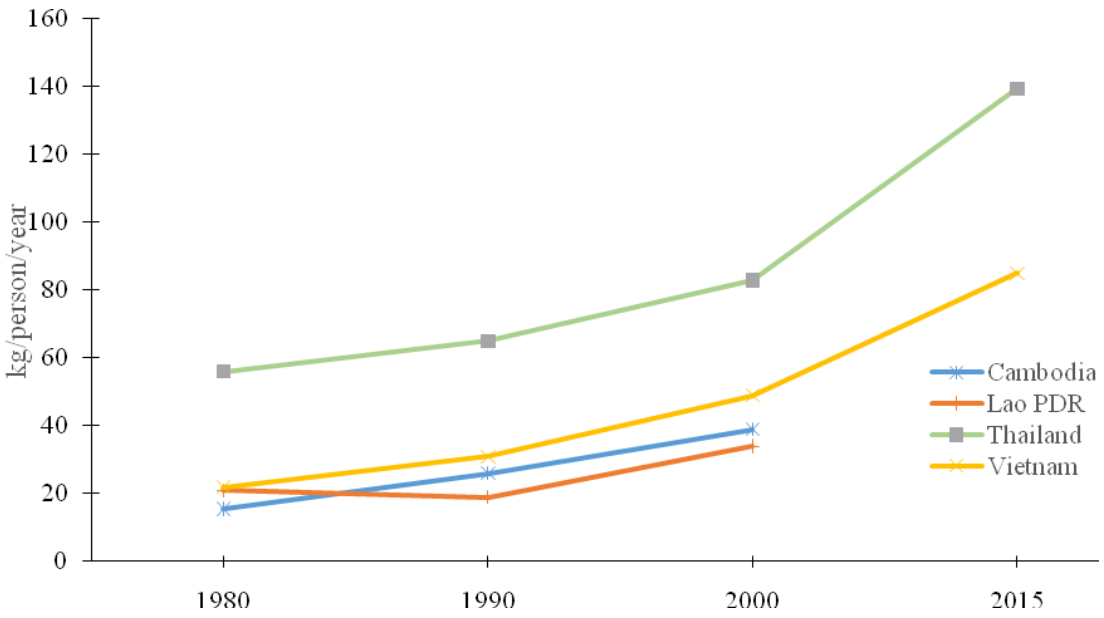

Figure 2.1 Historic and expected trends in per capita consumption of livestock products in Mekong countries from 1980 to 2015 (FAO, 2002)

The recent increasing demand for meat in Vietnam has outstripped production, resulting in higher prices for livestock products (Horne et al., 1996; Parsons et al., 2013). It has led to considerable interest among farmers in improving cattle production. In-order to meet the demand of the increased population growth rate and the higher standard of living, livestock production in Vietnam has advanced in both herd size and beef production. The elevated domestic demands for beef and beef products present a great opportunity for smallholder farmers to expand their future income base and production strategies within the cow-calf system, in an environmentally sustainable management system.

2.1.1 Vietnam livestock production

In 2014, the total population of ruminants, pigs and poultry was 7.7, 26.7 and 327.7 million head, respectively (GSO, 2014). Between 2000 and 2014, livestock grew in both size and productivity, with the exception of buffalos, whose population had decreased by 10% from 2.9 to 2.5 million head (Table 2. 1).

Table 2.1 Livestock population and production in Vietnam from 2000-2014 (GSO, 2014)

	2000	2005	2010	2011	2012	2013	2014
Population (million heads)							
Buffalo	2.9	2.9	2.9	2.7	2.6	2.6	2.5
Cattle	4.1	5.5	5.8	5.4	5.2	5.2	5.2
Pigs	20.2	27.4	27.4	27.1	26.5	26.3	26.7
Poultry	196.1	219.9	300.5	322.6	308.5	317.7	327.7
Production (1,000 t live weight)							
Buffalo meat	48.4	59.8	83.6	87.8	88.5	85.4	86.8
Cattle meat	93.8	142.2	278.9	287.2	293.9	285.4	292.9
Pork	1418.1	2288.3	3036.4	3098.9	3160	3217.9	3330.6
Poultry meat	292.9	321.9	615.2	696	729.4	746.9	828.1
Egg (million)	3771	3948.5	6421.9	6896.9	7299.9	7754.6	8297.5
Milk (1,000 t)	51.5	197.7	306.7	345.4	381.7	456.4	549.5

Overall, beef production in Vietnam has increased sharply within the last decade, from approximately 94,000 t in 2000, to 293,000 t LW in 2014, with annual production increasing at a rate of 15% (GSO, 2014). The dairy industry also increased sharply during the last 15 years with milk production increasing more than 10 times from 51,500t in 2000 to 550,000t in 2014. (Table 2.1)

2.1.2 Cattle production system

Cattle production is an important component of the smallholder farming system in Vietnam. Cattle are raised in extensive and semi-extensive systems (Eguienta, 2002) with multiple purposes including supply of beef, milk, draught power, fertilizer for use on crops and as a method to store capital (Eguienta, 2002; Hieu et al., 1994). The main cattle breeds in the region are local (Yellow) cattle and crossbreds between local and Zebu (*Bos indicus*) cattle. Zebu breeds are extremely well adapted to tropical conditions and the local feeding systems (Cunningham and Syrstad, 1987). However, these breeds, especially Yellow cattle, have a low average body weight, dressing percentage and milk production (Burns et al., 2001).

The basal diet of cattle in Vietnam is generally rice straw supplemented with green forage from grazed native grass or cultivated forages (Ba et al., 2005). As grazing land is limited, cattle usually graze on communal land, by the roadside and other areas unsuitable for crop cultivation (Cuong, 2010; Thang, 2010; Trach, 1998). Feed analysis of such diets indicates low crude protein and fermentable carbohydrate contents (Ba et al., 2008a). In addition, in some areas during the winter, cattle are almost solely fed rice straw with very little home-made concentrate (Thang, 2010). Therefore, this diet generally does not meet the nutritional requirements of the cow and leads to poor body condition, productivity, and reproduction performance. According to Huyen et al. (2010), the availability of feed resources strongly affected the number of cattle per farm, with approximately 50% of small households keeping less than three cattle (Tung et al., 2006).

2.1.3 The Cow-calf production system

A cow-calf system is a method of raising beef cattle in which a permanent herd of cows is kept by the farmer to produce calves for later sale (Womach, 1997). The primary goal

of the cow-calf system is to maximise the number of calves produced annually to match the elevated domestic beef demand and to generateprofit. The income from a cow-calf system is generated from the number of calves sold to the market in a year. The cow-calf system is essential for the production of beef in Vietnam because it supplies the mainstream market with calves between 5 and 6 months of age. These calves are either slaughtered to provide veal or grown and finished quickly by the other farmers to provide beef products. The impact of deficiencies in management skills or in the feeding system will affect beef supply. A comprehensive assessment of the cow-calf system is essential to assist in identifying areas in the system that would need addressing to combat the issue of low beef supply.

2.2 Feed resources for cattle in Vietnam

Feeding beef cattle has been a major challenge for smallholder farmers in Vietnam (Ba et al., 2013). In the traditional system, ruminants are usually fed on native pasture and crop residues, which are usually free and do not require establishment and maintenance (Horne et al., 1996). However, with an increased cattle population, these resources have become increasingly limited and farmers need to look for other feed sources such as cultivated forages and concentrate, and learn to manage and use their natural resources in an efficient manner.

The available feed resources for cattle in Vietnam are discussed as follows:

2.2.1 Grazing pastures

Vietnam has more than 10 million ha of agricultural production land (GSO, 2014). However, there is a lack of natural grazing areas. Population expansion and new economic activities have resulted in areas of native and naturalised pastures being converted to crops or building construction (Ly, 1992). Native pastures usually have low production and nutritive value (Hacker and Kerridgez, 1996). According to Hogan (1996), the adaptive ability of natural pastures usually correlates with decreased nutritional value in tropical climates. Improvement of natural pasture is expensive and has low efficiency because of water scarcity and prohibitive fertilizer costs. The high number of cattle and limited grazing lands without any grassland management has

resulted in over-grazing which in turn, causes land degradation, soil erosion, and impaired plant health and productivity (Radácsi, 2005). Regrowth of these grasses is not strong enough to dominate weeds (Hieu et al., 1994). Although the natural pasture is poor in nutritive value, yield, and is highly seasonally variable, it is still an important roughage source for cattle in many regions in Vietnam, especially in hilly areas (Ly, 1996; Mui, 2003).

2.2.2 Cultivated forages

With the decrease in grazing land, poor nutritive value, and low quantity of natural pasture, improving feeding using locally available feed resources and increasing new forages are key to improving beef cattle production (Ba et al., 2013). However, there is little evidence of widespread adoption. In 2013, there was only 43 thousand ha of cultivated forage, accounting for about 0.4% of total agricultural production land (GSO, 2014).

The yield, quality and adoption of cultivated forages had been studied at research institutions and on state farms across Vietnam and the results are very promising (Khanh, 1999). The first advantage of using forages is that they can supply a good quantity of high quality green grass. King grass or Elephant grass (*Pennisetum purpureum*) is widely accepted by farmers all over the country and can yield 22 t DM/ha/year (Ly, 1996). In Central Coastal Vietnam, from 2010, some new species such as Mulato II (*Brachiaria Hybrid cv. Mulato II*), TD 58 (*Panicum maximum cv. TD 58*), Paspalum (*Paspalum atratum cv. Terenos*), and VA06 (*Pennisetum purpureum cv. VA06*) were introduced to farmers, and resulted in yields 26 - 50 t DM/ha/year depending on the species (Ba et al., 2013). The development of forages can reduce grazing pressure, and therefore the risk of environmental damage from over grazing communal land could decrease (Ba et al., 2013).

2.2.3 Agricultural by-products

In crop-livestock systems, large amounts of cereal crop residues (straw, stubble) and food crop by-products with little alternative value (rejected fruit and vegetables, oilseed meals and cereal grains) are often available on a seasonal basis. Although the nutritional quality

of agricultural by-products can be low, their large quantity constitutes a very important potential for ruminant development in Vietnam (Ly, 1992).

Rice-straw, the most important crop residue feed for ruminants, is readily available throughout the country. In 2014, there was 7.8 million ha of paddy rice, with a total production of approximately 44.9 million t in Vietnam (GSO, 2014). With a straw-grain ratio of about 1.0 to 2.0 depending on the variety (Yoshida, 1981), this equated to around 45 to 90 million t of dry rice-straw in 2014. However, while some of the straw is used as cattle feed, some is used as fuel, fertiliser or just burnt after harvesting. Rice straw is low in energy, protein and vitamins but contains a high carbohydrate content which can be degraded by rumen microbes into volatile fatty acids - an important energy source for ruminants (Mui, 2003). Rice straw is usually dried in the field after harvesting, piled up and stored in the backyard over a long period. Cattle are often fed with rice straw at night or during the cold, rainy weather when grazing is not possible (Ly, 1996).

Maize, peanut and soya bean stems are also available in large quantities following harvest.However, because their harvesting time is short and storage that maintains quality is difficult, only little amounts are used as animal feed.

2.2.4 Concentrates

Where low quality grasses and crop residues are fed, concentrates are essential for correcting nutritional deficiencies and ensuring balanced diets. In intensive cattle production in Vietnam, concentrate is mostly fed to finish cattle. Rice bran, maize, cassava powder, fish meal, and urea are the most common concentrate feed sources (Dung et al., 2013). However, due to the expensiveness of concentrate feeds in tropical developing countries, their use must be efficient in order to achieve maximum profit (Kokkonen et al., 2004).

Concentrates have a significant effect on cattle feed intake. High concentrate levels in the diet typically increase DM intake (Haddad, 2005; Salim et al., 2002; Tufarelli et al., 2009), weight gain and improve feed efficiency, carcass characteristics, and reduce feed costs (Haddad, 2005). In Vietnam, most ruminant nutrition studies have concentrated on local cattle (Ba et al., 2008b), growing cattle (Trach et al., 2001; Trung et al., 2014),

fattening cattle (Ba et al., 2008a; Dung et al., 2013), dairy cattle (Vu et al., 1999) and very little on beef cows. Therefore, there is a dearth of information about the effect of supplementary feeding of beef cows on cow-calf performance, especially under on-farm management conditions.

Due to limitations in feeding resources, improved feed management and storage methods can be used to enhance the nutritive value of low quality roughage, reducing feed costs and dependence on other feeds (Mui, 2003). In the current cattle production system, roughages cannot serve as substitutes for supplementation. However, there is a need to use supplementation in an economically efficient way.

2.3 Nutritional requirements

2.3.1 Nutrient requirements of the cow

Matching the basic nutrient requirements is a pre-requisite for profitability in a cow-calf production system (Hersom, 2010). Supplying adequate nutrition is necessary for cow and calf health, calf growth performance, and especially, lactation performance of the cow. However, there are many factors that affect the nutrient requirements of the cow including body weight and physiological status of the non-pregnant, pregnant, non-lactating, and lactating cows (Moran, 2005). Therefore, a good understanding of the nutritional requirements of the cows is important for improving the efficiency of a cow-calf production system.

2.3.1.1 Nutrient requirement for maintenance

An animal is in a state of maintenance when its body composition remains constant, and is not working to produce wool, eggs or milk (McDonald et al. 2002). Nutrients needed for maintenance depend mostly on LW. Physical activities, physiological state, and environment temperature also add into the equation for meeting maintenance requirements (Moran, 2005). Grazing animals require from 25 to 50 % greater energy compared with stall-fed cows (McDonald et al. 2002). In addition, less productive animals use more of their energy intake for maintenance compared to highly productive cattle. Weather can also affect nutrient requirements by influencing feed intake and metabolic activity. Nutrient requirement increases when temperature is low. Mid

andsevere cold stress are estimated to increase maintenance requirements to supply body heat by 7 to 25 %, respectively (NRC, 2001). At the other end of the spectrum, cattle reduce their feed intake and movement activities when the temperature is high. The drop in feed intake can reduce productivity in high-producing animals, for example, decrease milk production in dairy cattle.

2.3.1.2 Nutrient requirements for reproduction

It is important to supply adequate nutrients to meet the requirements of pregnant cows to ensure adequate and proper development of the foetus, maintain cow body condition and facilitate a timely return to oestrus (NRC, 2000).

The energy required for gestation is initially very small in the first 190 days (NRC, 2001). However, in the last month of gestation, the energy requirement for gestation is approximately 56% of the total energy requirement (Hersom, 2010). The protein requirement becomes significant only in the last few months of pregnancy (Moran 2005), as 2/3 of the foetus growth occurs during the last two month of gestation (Hersom, 2010).

2.3.1.3 Nutrient requirements for milk production

The energy required for lactation is defined as the energy content in the milk produced. However, it is difficult to estimate milk yield in the beef cow because it is consumed by the suckling calf. Milk yield, fat and protein contents change during the lactation cycle, and thus the energy requirement for lactation changes accordingly (Hersom, 2010). Milk contains a high concentration of protein. The source of the protein in milk comes either from dietary sources or mobilisation of cow body tissue. Greater the mobilisation of lean tissue, the greater loss in body condition of the cow.

2.3.2 Nutrient requirements of the calf

Growth performance of the calf may strongly influence the profitability of the cow-calf production system. Nutrient quality and availability during pre- and post-natal periods play an important role in foetal and calf growth and development. Restricted nutrition and/or inadequate placental development during the latter half of gestation can slow down the growth of the bovine foetus (Bella et al., 2005). Thus, pre-weaning nutrition

also influences the growth performance of calves (Berge, 1991). However, the interaction between foetus and calf growth performance is not fully understood.

2.3.2.1 Nutrient requirements for foetal growth

During the pre-partum period, foetal growth and development are regulated via the dam by the placenta (Greenwood and Cafe, 2007). The functions of the placenta are to transport nutrients from the dam's blood into the foetus and remove excretory products from it. In the first phase of the gestation period, low or high nutrient intake may affect embryo survival. Low nutrient intake can change the progesterone and steroid hormonal profile that could in turn, change the uterine environment to the detriment of embryo survival (Abecia et al., 2006). Low and high levels of nutrition can alter systemic and follicular fluid hormonal concentration (O'callaghan et al., 2000), and have a negative effect on oocyte quality in experimental ewes (Grazul-Bilska et al., 2006).

Most growth of the bovine foetus occurs during the last trimester of pregnancy (Ferrell et al., 1976; Hersom, 2010), therefore, nutrient requirement becomes more significant during this time (Ferrell et al., 1983; Moran, 2005). Bovine foetal growth performance is adversely affected by the restriction of nutrition in the last period of pregnancy (Greenwood and Cafe, 2007). Inadequate nutrition of heifers and cows during both second and third trimesters of gestation (Cafe et al., 2006; Freetly et al., 2000) or last trimester only (Bellows and Short, 1978)can cause a significant reduction in calf birth weight. However, underfeeding of cows in the second trimester of pregnancy may not significantly affect calf birth weight (Freetly et al., 2000).

2.3.2.2 Nutrient requirements for pre-weaning calf growth

The major nutritional factors affecting pre-weaning calf growth are lactation performance of the dam, followed by the availability and quality of other feed resources such as pasture and supplementation (Greenwood and Cafe, 2007). Due to low milk yield of most Zebu cattle (Cunningham and Syrstad, 1987), cow milk yield typically reduces as the calves reach the mid-point towards weaning and a substitution effect of nibbling at pasture and concentrates takes over sole reliance on milk. It leads to a greater dependence on roughage towards weaning. Therefore, effects of underfeeding pre-

partum on weight at birth can be solved by adequate post-partum nutrition (Freetly et al., 2000; Hight, 1968). Similarly, Soto et al. (2001) reported that supplementing cows pre- and post-partum did not affect calf weaning weight. These results are in agreement with the findings of other researchers who observed that there was no effect of pre-partum supplementation on calf growth rate from calving to four months of age (Khan et al., 2002), or on the carcass composition of offspring 222 days post weaning (Stalker et al., 2006).

Hence, economic benefits of the cow-calf system can come from supplying adequate nutrition to cows, especially during the pre-partum period to optimise growth of foetus and calf (Alford et al., 2007). In addition, feeding management of the calf, such as eating practice, supplementing roughage feeds and concentrates, are important for improving calf growth performance.

2.4 Cow reproductive performance

Fertility performance is one of major economic importance in the cow-calf production system (Olori et al., 2002). Poor fertility results in a long CI and leads to economic losses (Van Arendonk et al., 1989). Fertility in cattle is affected by genetics, environment, disease and management factors such as nutrition. Reproductive performance in cows is mostly measured by age at first calving, fertility rate, conception rate at first service (CRFS, %), number of services per conception, calving to first service interval (CFSI), calving to conception interval (CCI) and CI(Melendez and Pinedo, 2007; Mostert et al., 2010; Rodriguez-Martinez et al., 2008).

2.4.1 Fertility rate

There are several factors that affect cow fertility. These include age, lactation status, breed, management and environment. For example, fertility rate is highest in 6 to 7 year old cows (Buck et al., 1976)as heifers have a lower pregnancy rate than older cows (Reynolds et al., 1979).

There are several ways to estimate fertility rate. Mukasa-Mugerwa (1989) reported that the most common way to estimate fertility rate is by calculating the percentage of mated cows that become pregnant (pregnancy rate) or finally calve (calving rate). However,

fertility rate can also be estimated by other means. Poock (2009) indicated that pregnancy rate (PR) is the number of cows pregnant out of the total number of cows eligible to become pregnant for each 21 day period during the year. The percentage non-return rate can also help to estimate PR.

In Zebu cattle, fertility rates are usually low, especially in the traditional management system. The low calving rate is possibly due to inadequate nutrition and lack of management skills. Therefore, improving cattle diet and management skills can have a significant effect on improving Zebu cattle fertility and reproductive performance. For example, Rennie et al. (1977) found that the calving rate of traditionally raised Tswana cattle (cattle post) was 46.4%, compared with 74.0% for cattle kept within fences to control breeding herds. To support this, Trail et al. (1971) reported that the fertility rates can reach 79% in Zebu cattle in Uganda where feed and water were available. *Bos taurus* and crossbred *B. taurus x B. indicus* also showed similar trends in the research reported by DeRouen et al. (1994) in which body condition score (BCS) at calving influenced PR ($P<0.03$), and cows with BCS 6-7 (on a 9 point scale) at calving had a higher pregnancy rates compared with cows with BCS of 4-5 (on a 9 point scale). To sum up, traditional management systems lead to poor fertility performance in cattle, and improving that system can have a significant impact on cattle condition and fertility performance. However, there was an opposite trend in high producing cattle, especially milking cows. Due to better nutrition, improved management and intense genetic selection in dairy cows, milk production increased sharply (Lucy, 2001). In contrast, there was a decrease in reproductive efficiency via decline in fertility rate in high producing dairy cow breeds such as Holsteins (Bousquet et al., 2004; Lucy, 2001; Rocha et al., 2010; Rodriguez-Martinez et al., 2008; Royal et al., 2000). For example, in the USA, conception rate at first service declined from 65% in 1951 to 40% in 1996 while milk production doubled from 4500 to 9000 kg/year over the same time period (Figure 2.2)(Butler, 1998). The same trend was also reported in The Netherlands, Spain and France (Bousquet et al., 2004; Jorritsma et al., 2000). Therefore, it is clear that the increasing milk yield can lead to a decrease in cow fertility (Lucy, 2001; Pryce et al., 2004). Pryce et al. (2004) also

reported that cows producing around 768 kg of milk have an increase of 4.46 days CI and a reduction of 0.41 in BCS.

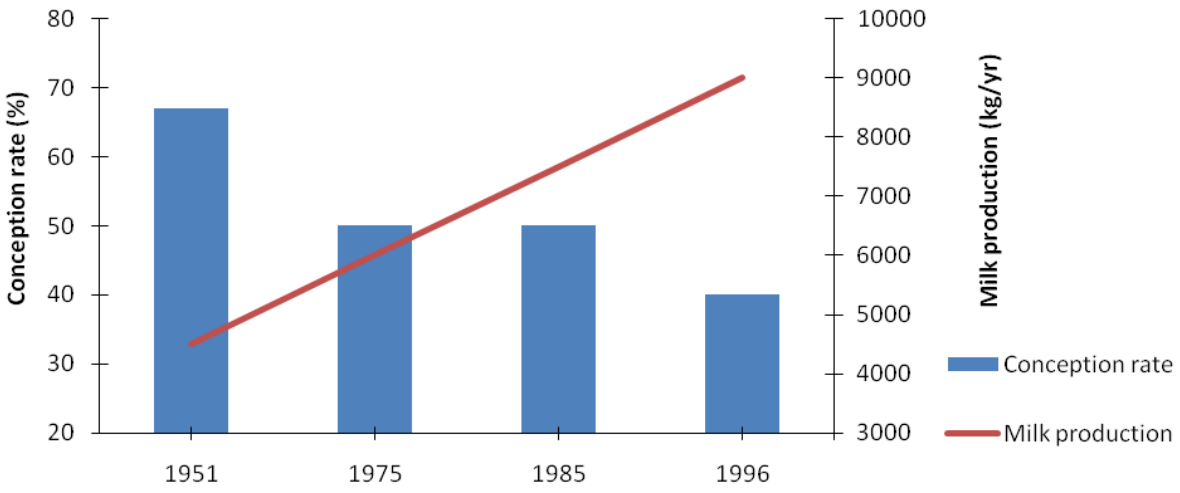

Figure 2.2The conception rate and annual milk production of Holstein dairy cows in New York from 1951 to 1996 (Butler, 1998).

2.4.2 Calving interval

Calving interval is the time between when a cow delivers a healthy and fully carried to term calf until the next calving (Poock, 2009). It is mostly used to evaluate the reproductive efficiency of dairy cows and as a selection tool for dairy breeds (Mostert et al., 2010). Calving interval is important because it impacts on herd replacement decisions, which are important for positive economic viability of the farm. Calving interval is influenced mostly by management practices such as feeding management, oestrus detection, and artificial insemination (AI) skill.

2.4.3 Body condition score

Cows are at risk of metabolic disorders and diseases, and decreased milk yield when they are too fat or thin. Therefore, optimum management of energy reserves is critical to economic success in the cow-calf system (NRC, 2001). Body condition score is used as a subjective determinant of body fat reserves of sheep, beef and dairy cattle (Lowman et al., 1973). There are several scales to determine BCS. In Australia, a 1 to 5 scale

iscommonly used, with 1 = severe under-condition, 2 = under-condition, 3 = good condition, 4 = over-condition, 5 = severe over-condition. This practice is popular because it is an accepted, quick and cheap method to assess the nutritional status of livestock (Popescu et al., 2009b; Waltner et al., 1993a). In addition, BCS can be used as a selection index to improve fertility because it has a moderate to high heritability of 0.2 to 0.3 (Jones et al., 1999) compared with reproductive traits such as CI, days to first service and conception rate that are typically less than 0.1 (Hoekstra et al., 1994). Pryce et al. (2001) concluded that BCS could be used as a management and selection tool to improve reproductive performance because of the strong relationship between BCS, lactation and reproduction.

2.5 BCS – fertility interactions

Several studies in dairy cows have been carried out on the effect of BCS on fertility (Gillund et al., 2001b; Roche et al., 2007), but the results are conflicting. For instance, Waltner et al. (1993) reported that BCS affects milk production but not reproduction, while other studies confirmed the close relationship between reproduction and pre-calving (Mouffok et al., 2013; Singh et al., 2009) and post-calving (Patton et al., 2007) BCS.

2.5.1 BCS and pre-partum nutrition

The level of nutrition during the pre-partum period usually influences BCS at calving. Richards et al. (1986) found that BCS at calving was the most important factor affecting pregnancy rate and oestrus interval. The greater the BCS at calving, the higher the pregnancy rate in cows (Lake et al., 2005; Rakestraw et al., 1986; Selk et al., 1988). The effect of BCS at calving is in both primiparous (Spitzer et al., 1995) and multiparous (Richards et al., 1986) cows. During the last 4 months pre-partum, Morrison et al. (1999) reported that BCS at calving in cows with a BCS score of 5 or higher (on a 9-point scale) did not affect the pregnancy rate. There is also a negative correlation between BCS at calving and calving to oestrus interval (Ciccioli et al., 2003; Richards et al., 1986). Additionally, Stockdale (2001) summarised in his review that better body condition during late pregnancy and at calving can have a positive effect on milk fat and milk yield.

2.5.2 BCS and post-partum nutrition

The BCS of cows at calving plays an important role in the efficiency of postpartum nutrition on reproduction performance. High energy supplementation post-partum can reduce calving to first oestrus interval (Wiltbank et al., 1964;Spitzer et al., 1995), and decrease the interval from calving to the first normal luteal phase (Lalman et al., 2000) in cows with low BCS at calving. However, the effect of energy supplementation postpartum was not significant on calving to first oestrus interval in cows with high BCS at calving (Richards et al., 1986; Marston et al., 1995; Spitzer et al., 1995).

In contrast, Rakestraw et al. (1986) indicated that cows with inadequate nutrient intake after calving exhibited oestrus times during the first 70 d postpartum, even cows calving in good condition. Ciccioli et al. (2003) also found that in the group of cows that calved with similar BCS of 4 to 5, animals fed to gain 0.9 kg/d for 71 d postpartum had a shorter interval to postpartum oestrus and ovulation, greater pregnancy rate compared with cows on grains targeted at 0.45 kg/d gain over the same period. Body condition score and CI are genetically correlated, -0.48 and -0.22 respectively in genetically selected dairy cows (Pryce et al., 2004). This means that as the BCS decreases, the CI increases.

2.6 Nutrition-fertility interactions

Nutrient supply affects cattle reproductive performance because nutrition has a significant impact on BCS, lactation yield and peak lactation of the cow and foetus development (NRC, 2000;Hersom, 2010). According to McDonald (2002), cattle reproductive performance is affected by early life nutrition. In young animals, poor nutrition can delay puberty age, particularly in goats (Fasanya et al., 1992) and cattle (Chelikani et al., 2003). In these studies, there was a significant effect of nutritional level on age at puberty but not on body weight changes. In contrast; however, Malau-Aduli et al. (2005) showed that nutritional level affects both age and body weight of goats at puberty.

There is extensive evidence that links level of nutrition pre- and post-parturition to postpartum reproductive performance. McDonald (2002) found that inadequate nutrition in cows in the last three months of gestation might affect calves by causing death *in*

*utero*or by reducing viability at birth. Underfeeding during late pregnancy also increased CI(Short et al., 1990;Ferrell, 1991), lowered milk production and decreased calf weight at weaning (Corah et al., 1975;Bellows and Short, 1978). However, the roles of energy, protein, as well as pre- and post-partum supplementation on cow reproductive performance are controversial. For instance, Robinson (1990) reported in his review that supplements with high protein content helped cattle to improve their reproductive efficiency. Additionally, adequate protein status pre-calving was reported to be essential for the production of high quality colostrum which is important for newborn calf health (Hersom, 2010). On the other hand, Davis et al. (1977) found that energy supplements during the pre-partum period reduced conception intervals more than protein supplements. Similarly, stored energy during the 3 months of pre- and post-parturition periods affects the length of postpartum anoestrus interval and probability of successful pregnancy (Chagas et al., 2007). Rutter and Randel (1984) indicated that increasing the level of post-parturient nutrient intake can decrease post-partum interval to oestrus from 58 to 35 days in beef heifers. However, other findings demonstrated that the postpartum interval in cattle depended strongly on pre-partum rather than post-partum nutrition (Bellows and Short, 1978). In a study by Galina and Arthur (1989), cow reproductive performance was improved by supplementing 8 weeks before calving to 8 weeks after calving. In contrast, Soto et al. (2001) found that the level of supplementation offered before and/or after calving did not improve pregnancy rate.

To sum up, the lack of adequate dietary nutrients pre- and post-partum can result in low cow fertility, sub-optimal reproductive performance and poor body condition of calves. However, there is conflicting evidence on the role of balanced nutrition pre- and post-partum on cow reproductive performance.

2.7 Summary of identified knowledge gaps and research objectives

There are many opportunities for smallholder farmers in Vietnam to meet the increased demand for beef to generate improved incomes. However, inadequate grazing land, unstable supply of traditional feed resources, increasing price of purchased feed and the unavailability of labour are major challenges that inhibit the development of cow-calf production system in SCC Vietnam. Therefore, it is important to understand the current

animal, feed and health management practices in order to chart innovative directions and strategies for further cow-calf research and development in SCC Vietnam.

Adequate nutrition supplied 3 months pre- and post-partum is essential for improving cow-calf performance. However, there is a dearth of information about the pre- and post-partum nutritional requirements of crossbred cows, as well as knowledge of the effect of supplementing beef cows during the pre- and post-partum periods on cow-calf performance under on-farm management conditions in Vietnam. A full understanding of the nutritional requirements of cows during pre- and post-partum periods and their response to dietary supplementation will have a significant impact on improving cow-calf reproduction systems, especially for smallholder households.

Therefore the research objectives needed to fill the identified knowledge gaps are:

1. To assess the cow-calf production system in order to understand the current animal, feed and health management practices in SCC Vietnam.
2. To determine the impact of supplementing cows from the beginning of the last trimester of gestation through to 3 months post-partum on cow-calf productivity in SCC Vietnam. The research hypothesis tested were:

i. Adequate nutrition 3 months pre- and post-parturition will improve cow BCS and LW;
ii. Adequate cow nutrition in the 3 months pre- and post-parturition will increase calf LW, body length and chest girth at birth and 90 days;
iii. Cow reproductive performance will be improved by supplying balanced nutrition 3 months pre- and post-parturition

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Chapter 3 Evaluation of the cow-calf production system in Nhon Khanh Commune, Binh Dinh Province, South Central Coastal Vietnam

Abstract

The objective of this study was to describe the cow-calf production system in South Central Coastal (SCC) Vietnam in terms of feed resource availability, feed and cattle management, adoption of new technologies and limitations to cow-calf production. Therefore, a survey was conducted in Nhon Khanh commune from January to August 2014 to collect the information about the current cow-calf system in this area. A total of 103 households were interviewed. In addition, 475 cows were assessed for body condition score (BCS) and reproductive performance in January and July 2014. Calves (165, 0-6 months old) were weighed and their body length and chest girth measured to assess growth rate.

Feed shortages were believed by smallholder farmers to be the biggest issue in cow-calf production.Approximately 50-70% of smallholders faced feed shortages in December and January, and over-grazing of communal grazing lands was an additional issue. Body condition score was negatively correlated with CI and daily duration of grazing. Cows spending more time grazing had a lower BCS and longer CI. Techniques such as vaccination, parasite prevention, and mineral and vitamin supplementation are related to more intensive production. Concentrates were used by almost all the smallholder farmers surveyed. However, the traditional cooking method of concentrates may reduce the efficiency of supplementation as it increases water filling effects in the rumen and potentially decreases dry matter intake of cattle. To sum up, the lack of nutrition management is the biggest factor constraining the cow-calf production system. Therefore, research on cow-calf nutrient requirements, using suitable supplements, and applying

new feeding technologies should be a priority in order to improve cow-calf production in South Central Coastal Vietnam.

3.1. Introduction

Agriculture is the dominant source of livelihood for 47% of Vietnam's 90 million people (GSO, 2014). The livestock industry is an important income generator for the agricultural sector, with more than 90% of the national cattle herd raised by smallholders (Huyen et al., 2011). Historically, cattle were raised for long-term savings and integrated with crops to utilise crop by-products for meat, manure and draught power (Phung and Koops, 2003). This integrated system is important mainly because high yields can be achieved at minimum costs, which is particularly necessary for poor farming communities. The recent increase in demand for beef in Vietnam (Ba et al., 2013) has outstripped supply, resulting in higher prices for both breeding stock and animals for slaughter. This has led to considerable interest among smallholders to adopt and transition from being mere cattle keepers to beef producers. The elevated demand for beef and beef products domestically present a great opportunity for cattle producers to increase their incomes. However, the deficiencies in the system that affects beef supply need addressing before this opportunity can be realised. A comprehensive assessment of the cow-calf system is essential to identify strengths and weaknesses. From the characteristics of the current production system, new technologies and management skills can be added to assist in improving productivity and profitability for smallholder farmers and ensure beef supply meets demand in Vietnam.

A cow-calf system is a method of raising beef cattle in which a permanent herd of cows is kept by a farmer to produce calves for sale (Womach, 1997). The success of this system is dependent on the cow's reproductive efficiency such as; how quickly a cow returns to oestrus, the number of services before conception and how quickly a calf attains market weight. These goals are accomplished through sound nutrition, health and breeding management. Much of the feed resources for cow-calf systems are supplied through the integration of crop and livestock enterprises. This integration maximises

returns from limited land to improve income sustainability. Improving the efficiency of the crop and animal integrated system can ensure improved animal output, thus driving the profitability of cow-calf systems in Vietnam. However, there are constraints and obstacles that present great challenges to the cow-calf production system in Vietnam, in particular feed availability and quality.

Cattle production plays an important role in farming systems in South Central Coastal (SCC) Vietnam. This region accounts for 13.4% of the country's land area but 23% of the total number of cattle (GSO, 2014). The basal diet of cattle in SCC Vietnam is generally native grass, cultivated forages (mostly King grass), and crop by-products, particularly rice straw (Ba et al., 2005). These feedstuffs are low in key nutrients, i.e. protein and energy, important for growth and development of the calf to the required market weight. In addition, the harsh climatic conditions (high temperature, long dry season and waterlogging during the wet season) in SCC Vietnam result in inconsistent forage growth and availability. Limited nutrition and poor management practices can lead to a low cow-calf performance; such as a long CI and slower calf growth rates.

Nhon Khanh commune represents a typical cow-calf production area in SCC Vietnam and is an ideal starting point to examine these issues. The objective of this study was to assess the cow-calf production system in Nhon Khanh commune to understand the current animal, feed and health management practices and to highlight directions and strategies for further cow-calf research and development in SCC Vietnam.

3.2. Materials and methods

All experimental procedures were in accordance with the University of Tasmania Animal Ethics Committee guidelines, the 1993 Tasmania Animal welfare Act, and the 2013 Australian Code of Practice for the Care and Use of Animals for Scientific Purposes. The human ethics application (H0013683) was approved by the Tasmania Social Sciences Human Research Ethics Committee on 04 February 2014. The animal ethics application (A13695) was approved by University of Tasmania Animal Ethics Committee on 13 December 2013.

3.2.1 The study area

This study was conducted in Nhon Khanh commune (14°10′N, 109°0′E), Binh Dinh province, SCC Vietnam. Nhon Khanh has a land area of 859 ha and a population of 9552 people. Nhon Khanh was also selected because it is broadly representative of integrated crop-livestock cow-calf systems in SCC Vietnam. In 2014, there were 2042 head of cattle and 26 head of buffalo recorded in the commune (Nhon Khanh People's Committee, 2014). The main crops grown in the region are rice, maize and peanut. Provincial and local Department of Agricultural and Rural Development (DARD) officers supported the selection of this commune as it is an important source of calves for Binh Dinh province.

The research included two main activities: 1. A survey of the cow-calf production system and 2. Cow-calf monitoring activities in Nhon Khanh commune

3.2.2 Survey of the cow-calf production system in Nhon Khanh commune through on-farm interviews

A total of 103 households in Nhon Khanh commune were interviewed. A stratified random sampling method was used to select households that were representative of the agricultural system of this area, based on the following criteria: at least one cow-calf unit present on the farm, a willingness to participate and have well-recorded data on cow performance and management practices. The interview focussed mainly on two themes: the current cow-calf production system (people, cattle, land, breeding method, and cattle fertility) and feeding management. Smallholder farmers with cattle were interviewed

during the daytime in their houses and asked for information about their cow-calf in front of their cattle pens to help the interviewer distinguish which cattle were to be monitored. The respondents were asked to rate their various sources of income, production constraints and factors affecting calf value on a 1 to 4 scale (1 = unimportant,2 = less important, 3 = important, and 4 = very important). To determine the feed intake (both roughage and supplement), farmer was asked how much they fed their animal on a fresh weight basis. Sub-samples of each feed were collected to determine DM content.

To define the cattle feeding system, farmers were judge to apply a grazing system if their cattle grazed more than 2 h /d, and a stall-feeding system if less than 2 h/d. The reason to choose 2h/d is because it is an average time for cattle to go to the river for bathing and return. Bathing cattle is a common management option in Nhon Khanh commune. Cows are bathed in the edge of the river in the morning.

Some general information about the commune was collected from commune officials, Department of Agricultural and Rural Development(DARD) officers and veterinarians before the interview and included: commune population, total area, agricultural area and number of cattle.

3.2.3 Monitoring cow-calf production systems in Nhon Khanh commune

3.2.3.1 Feeding management of cows

Twenty pregnant cows (known to be in their 3rd trimester of pregnancy by collating the mating date from survey data) were selected for this activity. Initial BCS was assessed visually using a five-point scale (1 = severe under-condition, 2 = under-condition, 3 = good condition, 4 = over-condition, 5 = severe over-condition) with increments of 0.25 (Lowman et al., 1973). Liveweight was measured using a cattle scale (FX 15 Iconix). Cows were weighed in the 8^{th} month of pregnancy, in the morning before feeding. The feed intakes of basal and supplementary feeds were monitored on four occasions at weeks 30, 32, 34, and 36 pre-partum.Each occasion involved three consecutive days of monitoring, which included weighing the concentrate and roughage before feeding out to the cows in the morning and evening. Residuals were weighed and recorded the following morning.

3.2.3.2 Measurement of cow performance

A total of 183 cows in January and 292 cows in July 2014 were assessed for their reproductive performances. January and July were chosen because they represented two different seasons; dry and wet in Nhon Khanh when there is potentially the greatest difference in quality and quantity of available feed resources. Body condition scores were recorded individually and CI were determined by recording breeding and calving dates.

3.2.3.3 Measurement of calf performance

Measurement took place between March and September 2014. A total of 165 calves from 0 to 6 months old of age were weighed (FX 15 Iconix scale) and body length and chest girth measured to assess growth rate. Age, sex and the breed of calves were recorded.

3.2.4 Dry matter content of feed samples

Sub-samples of all feeds offered were collected on-farm. Offered feeds were collected in the morning before feeding and refusals feeds were collected the next morning. Samples (both feeds and residual) were dried to a constant temperature at 60 ^{o}C in a fan-forced oven (Memmert, Germany) for 48 h until constant weight was achieved. The percentage DM was computed by dividing the final weight of samples by the initial weight, then multiplying by 100.

3.2.5 Statistical analysis

Analyses of farmers response, cow body condition, and cow calf performance were conducted in SPSS 21 (SPSS, 2012), including mean, median, minimum, maximum and range values. For the cow-calf data, to obtain a multivariate view of all variables, the means of all variables were standardised, and subjected to principal component analysis (PCA) in Minitab 16 (Minitab, 2010). A biplot for the first two principal components was constructed using the method of Gabriel (1971).

Analysis of covariance (ANCOVA) using Proc GLM (SAS, 2014) tested for equality of regression slopes for different mating methods. The interaction between calf age and mating method was used to access whether slopes were homogenous. If $P>0.05$ for calf

age * mating method, it was concluded that there was no evidence for heterogeneity among slopes.

3.3. Results

3.3.1 Survey of smallholder farmers in Nhon Khanh commune

A characterisation of the cow-calf production system in Nhon Khanh commune is presented in Table 3.1 . The mean number of people per household was 4.5 and the average number of labourers per household was 2.4. The farm size was 3193 m^2 land, including 584 m^2 of sown forage. The average number of labourers was greater than the number of cows, with a ratio of 1.3:1. Nearly half of the smallholder farmers in Nhon Khanh commune grazed their cows, for an average of 3.4 h/d.

Table 3.1 Means of population, labour, cows, land, forage area, and grazing time of surveyed households in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Indicators	N	Mean	Median	Range	SD
Household size (people/household)	103	4.5	4	1-12	1.7
Total labour (people/household)	103	2.4	2	0-7	1.4
Total cows (cows/household)	103	1.9	2	1-5	0.9
Total land (m^2/household)	103	3193	2750	350-10250	1933
Forage area (m^2/household)	64	584	500	9-1500	355
Grazing hours (h/d)	45	3.4	3	2-7	1.9

Different sources of household incomes are represented in Table 3. 2. The two main sources of income for smallholder farmers in Nhon Khanh commune were beef production and crop production. Fifty four percent of the households surveyed rated the cow-calf system as a very important contributor of household income, while 21% rated crop production as very important. Government jobs, private employment and other livestock were unimportant sources of income in this commune.

The level of farming intensity and technological advancement is indicated by the management and technology options adopted by smallholder farmers (Table 3.3). Bathing cattle, vaccination, and salt supply were the most common activities, answered

positively by 98%, 87%, and 82% of surveyed smallholder farmers, respectively. Adoption of new technologies such as parasite prevention (65%) and artificial insemination (AI; 48%) were moderately common in Nhon Khanh commune. However, management practices such as mineral and vitamin supplementation, and early weaning are uncommon.

Table 3.2 Smallholder farmer views on the importance of income sources in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Farmers were asked to rate each source of income as unimportant, less important, important, or very important.

Income source	Unimportant (%)	Less important (%)	Important (%)	Very important (%)
Beef (cow-calves)	0.0	2	44	54
Crops	6	30	43	21
Other livestock	31	37	30	2
Government job	83	8	7	2
Private job	94	2	4	0
Other	46	21	21	12

Other: Fishery, part-time job

Table 3.3 Management and technology options for cow-calf production in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Indicators	Implementation (% of households)	Grazing system (% of households)	Stall-feeding system (% of households)
Bathing cattle	98	45	53
Vaccination	87	39	48
Salt supply	82	35	47
Parasite prevention	65	27	38
Artificial insemination	48	28	20
Record breeding date	52	20	32
Water supply	42	17	25
Vitamin supplement	26	12	15
Mineral supplement	12	3	9
Apply early weaning	2	0	2

Farmers in Nhon Khanh commune implementing a stall-feeding system tended to apply more management and technology skills for cow-calf production than famers favouring a grazing system. The exception to this was artificial insemination, which was commonly utilized in grazing systems.

Farmers identified a number of perceived constraints to cow-calf production, including lack of capital, lack of feeding resources, labour availability, management knowledge,

disease control, and market constraints (Table 3. 4). Availability of feed resources was overwhelmingly believed to be the most important factor constricting the cow-calf production system. Other important limitations to production included capital and management knowledge. Disease, labour, and markets were not considered by smallholder farmers to be important constraints.

Table 3.4 Farmers' views on the constraints to cow-calf production in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Farmers were asked to rate each potentially limiting factor as unimportant, less important, important, or very important.

Limitation	Unimportant (%)	Less important (%)	Important (%)	Very important (%)
Feed resources	0	4	28	68
Capital	2	34	52	12
Management knowledge	1	48	45	6
Disease	1	88	9	2
Labour	4	85	10	1
Market	5	92	3	0

The annual availability of cattle feed resources and periods of shortage of feed resources in Nhon Khanh commune are shown in Figure 3.1.

There was a high diversity of feed resources but their availability strongly depended on weather and season of cropping. All grazing grass, native grass, cultivated forages and agricultural by-product such as rice straw, peanut straw, maize stover were used as roughage feed.

Rice straw and concentrate were used by almost all smallholder farmers surveyed. Cultivated forage, grazing, and native grass were supplied by 50%, 40%, and 20% of households in Nhon Khanh commune throughout the year. However, these percentages went down by 5 to 10% from October to January. The availability of maize stem and peanut stem depended on seasonal harvesting. Peanut is harvested once per year, in March or April, whilst maize is planted twice, and is harvested in March and from June to September. A number of households face difficulties finding enough feed for cattle,

particularly from October until January. The feed shortage was serious during January, with over 70% of surveyed farmer indicating that they could not supply enough feed for their cattle.

The short term solutions that smallholder farmers use to deal with feed shortage are described in Table 3.5. Most smallholder farmers resolve the issue of short term feed shortages by storing more by-products and/or supplementing cattle with concentrates (91%). Only 4% of farmers increased the time spent on cut and carry of native grasses, and no smallholders reported extending their area of cultivated forages (Table 3.5).

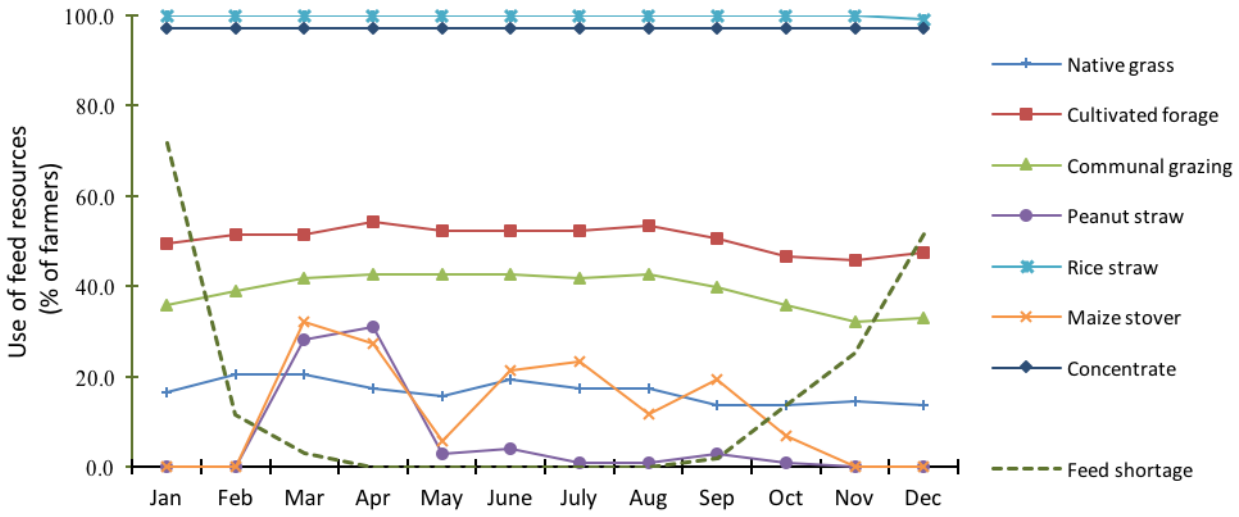
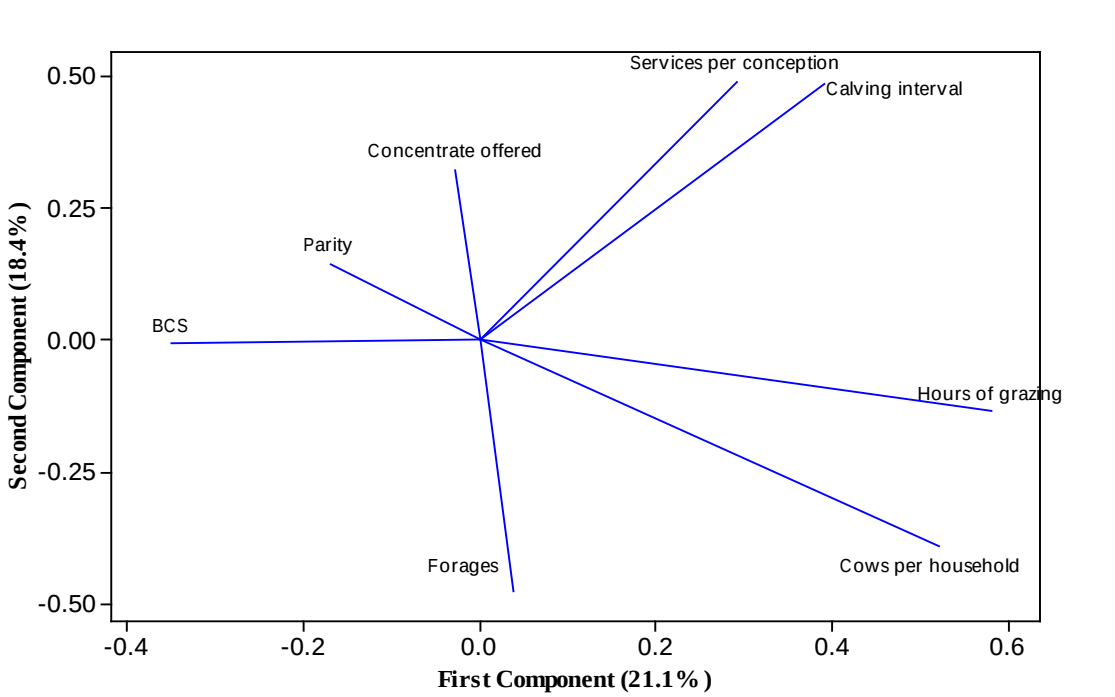


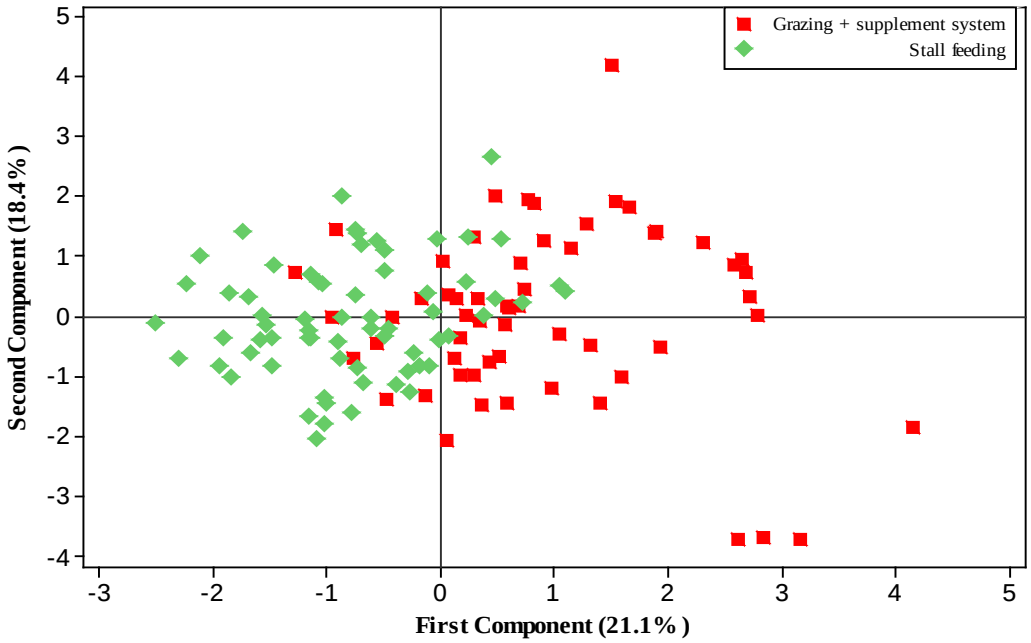
Figure 3.1 Fluctuations in feed shortages and cattle feed resources in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Table 3.5 Short term responses of surveyed farmers for dealing with feed shortage in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Solution	Implementation (% of households)
Storing more by-product (%)	93
Supplying more concentrate (%)	91
Cut and carry (%)	4
Planting additional forages (%)	0
Other (%)	2



(A)



(B)

Figure 3.2 Plots of principle component 1 versus principle component 2, based on surveyed households in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. The loading plot (A) shows the eigenvector of each characteristic. The score plot (B) shows the predominant cow-calf husbandry system, grouped by into either grazing and concentrate supplement, or stall feeding. Each point in panel B represents an individual cow.

The relationship between cow management and indicators of cow fertility was further examined using principal component analysis. The first two principal components accounted for 39.5% of the total variance. Figure 3.2 is the biplot for the first two components and shows the relationship between cow management characteristics (Figure 3.2A) and cow-calf husbandry system (Figure 3.2B). In the loading plot (Figure 3.2A), the cosine of the angle between two characteristics approximates their correlation. Thus, lines that are clustered are positively correlated and lines at 90^{o} to each other are uncorrelated.

The location of sample points (individual cows) on the score plot (Figure 3.2B) also contributes to the understanding of the relationship between the husbandry system and cow management characteristics. Clear groupings of grazing and stall feeding cows are evident. Cows managed predominantly in a grazing system tended to cluster in the same half of the plot, in contrast to stall fed cows focused on the opposite side. Households implementing a grazing system generally had more cows, cows with lower parity and BCS, and had longer CI compared with stall-fed stock.

The number of cows per household was strongly negatively correlated with body condition score, a larger forage area, and a longer grazing time (Table 3.6). Calving interval was positively correlated with service per conception.

Table 3.6 Multi correlation analysis for cow-calf production characteristics based on surveyed households in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

	Cows/hh	Parity	BCS	Ser/conc	CI	Forages	Grazing time	Conc. offered
Cows/hh		- 0.11	- 0.25***	- 0.02	0.06	0.32***	0.39***	- 0.03
Parity	- 0.11		- 0.08	0.15	- 0.04	0.03	- 0.21**	0.06
BCS	- 0.25***	- 0.08		- 0.03	- 0.10	0.04	- 0.12	- 0.03
Ser./conc.	- 0.02	0.15	- 0.03		0.37***	- 0.05	0.08	0.00
CI	0.06	- 0.04	- 0.10	0.37***		- 0.11	0.12	0.10
Forages	0.32***	0.03	0.04	- 0.05	- 0.11		- 0.11	- 0.09
Grazing time	0.39***	- 0.21**	- 0.12	0.08	0.12	- 0.11		- 0.13
Conc. offered	- 0.03	0.06	- 0.03	0.00	0.10	- 0.09	- 0.13	

** Significant at a probability level of 0.01.
*** Significant at a probability level of 0.001.
Cows/hh: cows per household, Ser./conc.: Service per conception, CI: Calving interval, Conc. offered: concentrate offered.

The main supplementary feeds used and their average daily intakes are presented in Table 3.7. Rice bran, maize powder, and rice grain were the most common concentrate sources with over 80% of households feeding these each day, followed by commercial concentrate (26%), and cassava powder (12%). Typically, 0.4 to 0.5 kg of each supplement was offered per day. The most expensive supplement was commercial concentrate, and the cheapest supplement was cassava powder.

Table 3.7 Supplementary feed stuffs used by households (HH) for feeding cattle in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Feed source	Quantity of feed offered (kg/ DM day)					Price (VND/kg DM)
	%(HH)	Average	SD	Median	Range	
Rice bran	84	0.41	0.28	0.34	0.1-1.7	6,088
Rice grain (cooked)	81	0.48	0.29	0.50	0.1-1.5	9,000
Maize powder	80	0.44	0.27	0.47	0.1-1.4	7,553
Commercial concentrate	26	0.46	0.30	0.40	0.1-1.0	13,000
Cassava powder	12	0.52	0.40	0.32	0.2-1.4	5,500

Currency: 1 AUD = 16.500 VND

Table 3.8 Body condition score (BCS) and reproductive performance of cows owned by smallholder farmers in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Indicator	n	Mean	SD	Median	Range
Cow BCS (both seasons)	475	2.9	0.5	3.0	1 – 4.25
Cow BCS in January	183	2.6	0.5	2.5	1 – 4
Cow BCS in July	292	3.1	0.4	3.0	1.75 – 4.25
Cow parity (#)	458	3.9	2.6	3.0	0-13
Services per conception (#)	160	1.5	0.7	1.0	1– 5
Conception at 1st service (%)	160	61	-	-	-
Calving to first heat interval (d)	137	131	45	124	55 – 245
Calving to conception interval (d)	137	147	48	142	60 – 280
Calving interval (d)	137	434	48	429	347 – 567

Cow BCS, services per conception, percentage of conception at first service, calving to heat interval, calving to conception interval, and CI are important indicators to evaluate the reproductive performance of cows. The average BCS of cows in Nhon Khanh commune was 2.9 on a 5-point scale. There was a significant ($P<0.05$) difference in BCS of cows between January and July. The cow BCS in January (2.6) was slightly lower

than in July (3.1). The range of cow BCS in January was also wider than in July (Table 3.8). Cow BCS from pre- to post-calving in January and July are shown in Figure 3.3, and demonstrate a declining BCS from pre- to post-partum phases,with the BCS lower. Figure 3.3 also indicates a statistically significant (P<0.05) lower BCS in January for cows of all phases (Table 3.9). The average of cow parity was 3.9, and the median was 3.0 (Table 3.8). The service per conception was 1.5 and the conception rate at the first service was 61%. The average interval from calving to first heat was 131 d and the average calving to conception interval was 147 d. The average CI was 434 d and ranged from 347 to 567 d.

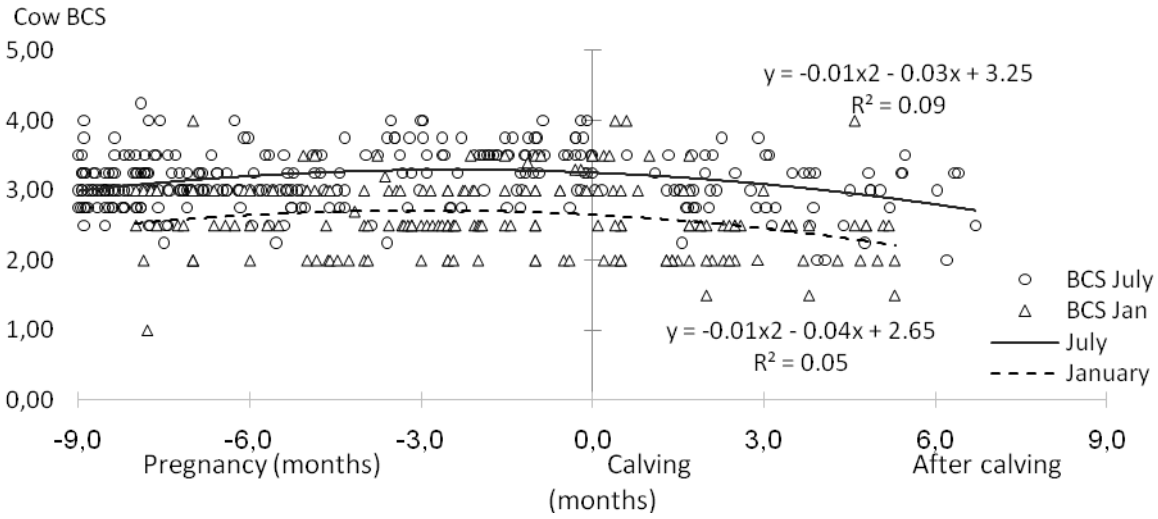


Figure 3.3 Body condition score of cows pre- and post-partum at two different times of year (January and July). Each point represents an individual cow. Lines are polynomial regressions.

Table 3.9 Analysis of covariance for cow BCS assessing month of pregnant x time, and calf weight assessing age * mating method interaction.

	n	Numerator df	Denominator df	F value	p-value
Cow BCS	464	1	461	3.09	0.08
Calf weight	109	1	105	7.17	0.009

The three major factors that smallholder farmers believed to affect calf pricing in Nhon Khanh commune were calf condition, calf breed, and the market (Table 3.10). Calf

condition is a subjective visual assessment of calf physical body conformation. Calf condition was rated by 52% of surveyed smallholder farmers as very important, whereas less smallholder farmers rated breed of calf that (20%) or the calf market (13%) as very important. Only 4% of smallholder farmers rated traders or calf weight as a very important factor affecting calf price. In 2013, 140 calves were sold at 6 months old, at an average price of 14.3 million VND per calf (nearly $867 AU) (Table 3.11). Male calves contributed around 90% of total sales, and were sold at an average age of 5 months, and an average price of 14.4 million VND ($872 AU). Female calves were on average sold older (10 months), at a slightly lower price (13.8 million VND, $836 AU) than male calves.

Table 3.10 Farmers' views on the factors affecting calf pricing in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Farmer were asked to rate the affect each factor has on calf pricing as unimportant, less important, important, or very important.

Effect on calf price	Unimportant (%)	Less important (%)	Important (%)	Very important (%)
Calf condition	3	7	38	52
Calf breed	3	16	61	20
Market	3	66	18	13
Traders	3	70	23	4
Weight	3	52	41	4

Table 3.11 The selling age and price of calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

	Calf	Male calf	Female calf
n	140	124	16
Selling age (month)	6.0	5.0	10.0
SD	2.0	1.0	3.0
Median	5.0	5.0	8.5
Min	3.0	3.0	4.0
Max	18.0	8.0	18.0
Price (million VND)	14.3	14.4	13.8
SD	2.6	2.5	3.0
Median	15.0	15.0	13.5
Min	5.4	5.4	8.0
Max	23.5	23.5	20.0

Currency: 1 AUD = 16.500 VND.

3.3.2 Monitoring cow-calf production systems

Feeding method:

Roughage and supplements were typically fed two times per day, at 7 am and 5 pm. Cattle were washed and grazed for around 2 h in the morning and spent about 2 to 3 h grazing in the afternoon. On average, cows grazed approximately 4.8 h/d on communal land (Table 3.12). Rice straw was usually fed in addition to cattle at night.

The feeds offered to animals are shown in Table 3.13. Two supplementary feeding methods were used in Nhon Khanh commune. The most common method (80%) was cooking, where rice grain was mixed with chopped water spinach, salt, and water, and cooked for 2-3 h. Before feeding, other concentrates such as rice bran, maize bran, or cassava meal were added. The second feeding method was to mix concentrates directly with water. Rice bran, maize bran, or cassava meal were mixed with salt and water (1 kg concentrate to approximately 15 L of water) and fed to cattle immediately.

Rice straw was the main roughage fed with 78% of householders fed for cattle. The average daily DM intake of the cows was 6.7 kg (5.9 kg of roughage feed, and 0.8 kg of concentrate), equivalent to 1.8% of body weight (Table 3. 13). This daily DM intake does not include any intake from grazing because of the difficulty of estimation.

Table 3.12 Means of pre-calving weight, and BCS, and grazing time of cows in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

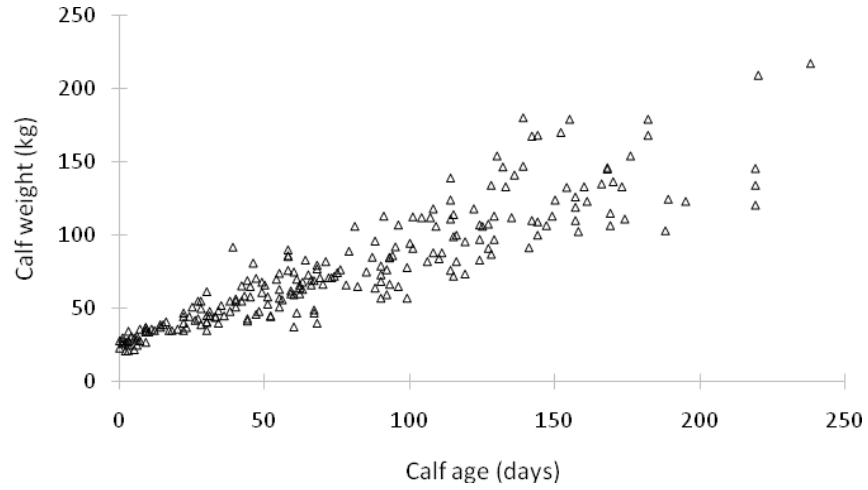
Cow characteristics	n	Mean	SD	Median	Min	Max
Grazing time (h)	20	4.8	2.6	4.6	1.0	9.5
Pre-calving cow weight (kg/head)	20	359	53	349	276	453
Pre-calving cow BCS	20	2.6	0.3	2.6	2.2	3.0

Table 3.13 Percentage of households(HH) (n = 20) using different feed sources and the average amount offered in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam.

Feed source	% HH	Mean	SD	Median	Min	Max
Roughage Offered						
Rice straw (kg DM/d)	78	4.75	2.58	4.55	1.01	9.47
King grass (kg DM/d)	44	1.88	1.3	1.24	0.78	3.96
Native pasture (kg DM/d)	28	2.26	1.46	1.8	1.16	4.8
Maize stover (kg DM/d)	22	0.77	0.26	0.86	0.41	0.96
Water spinach (kg DM/d)	67	0.36	0.18	0.38	0.1	0.71
Peanut straw (kg DM/d)	11	2.92	0.32	2.92	2.69	3.14
Total roughage intake (kg DM/d)	100	5.9	2.6	6.2	2.3	12.6
Concentrate Offered						
Rice bran (kg DM/d)	56	0.66	0.64	0.46	0.1	2.13
Rice grain (kg DM/d)	72	0.31	0.17	0.31	0.05	0.62
Maize bran (kg DM/d)	44	0.35	0.25	0.3	0.12	0.92
Cassava meal (kg DM/d)	17	0.33	0.13	0.3	0.22	0.47
Salt (kg DM/d)	56	0.08	0.07	0.06	0.02	0.2
Total concentrate intake (kg DM/d)	100	0.82	0.55	0.67	0	2.1
Total feed offered (kg DM/d)	100	6.7	7.3	6.5	2.7	14.3

The variance of calf weight increased over time (Figure 3.4A), therefore a log e transformation of both x and y variables was applied (Figure 3.4 B). There was a strong relationship ($r^2 = 0.87$) between calf age and weight (Figure 3.4B). The regression between calf weight and calf body-length, chest girth is presented in Figure 3.5. There was a strong relationship between calf weight and body length ($r^2 = 0.82$), and an even stronger relationship between calf weight and chest girth ($r^2 = 0.95$).

A)



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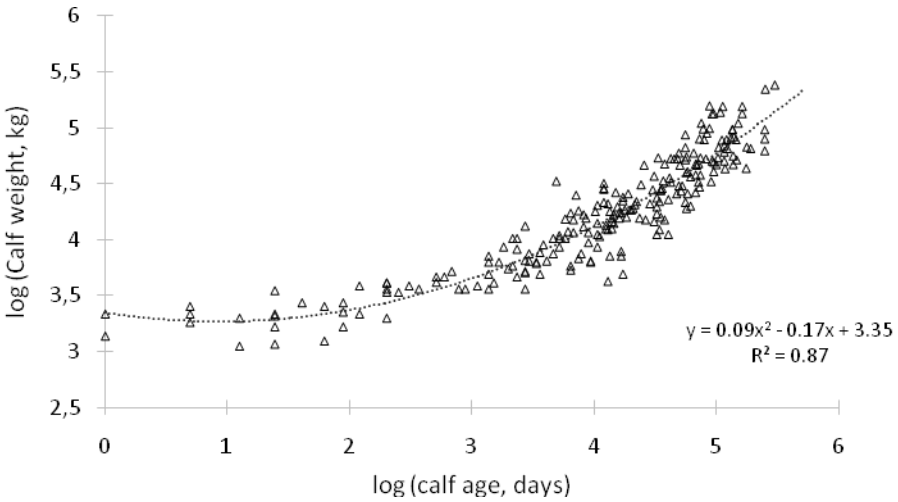

Figure 3.4 Regression analysis of age and weight (A), and log (calf age) and log (calf weight) (B) of 0 to 240 day old calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Each point represents an individual calf. Line are polynomial regressions.

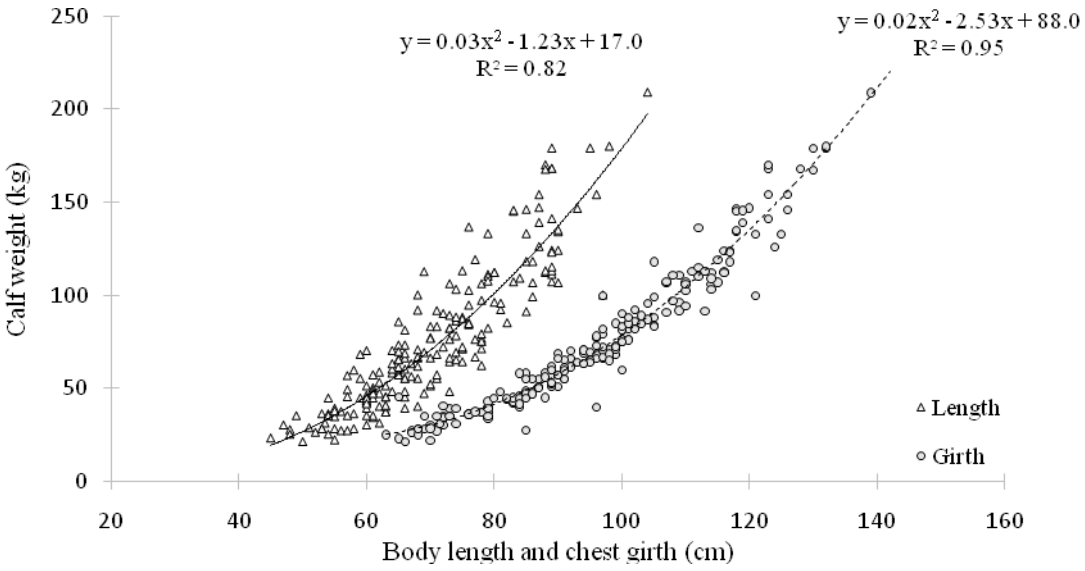

Figure 3.5 Regression analysis of calf body length, and chest girth, and calf weight (kg) of 0 to 240 days old calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Each point represents an individual calf. Lines are polynomial regressions.

The relationship between age and weight of calves of mating by different methods is shown in Figure 3.6. The y-intercept is very similar for both lines, and means that the birth weight for both groups of calves was similar (approximately 27 kg). However, thereafter the lines diverge due to different slopes, which correspond to different growth rates of the two groups. There was a significant difference ($P<0.05$; Table 3.9) between these regression lines, meaning that the growth rates of calves born through natural mating and AI are different.

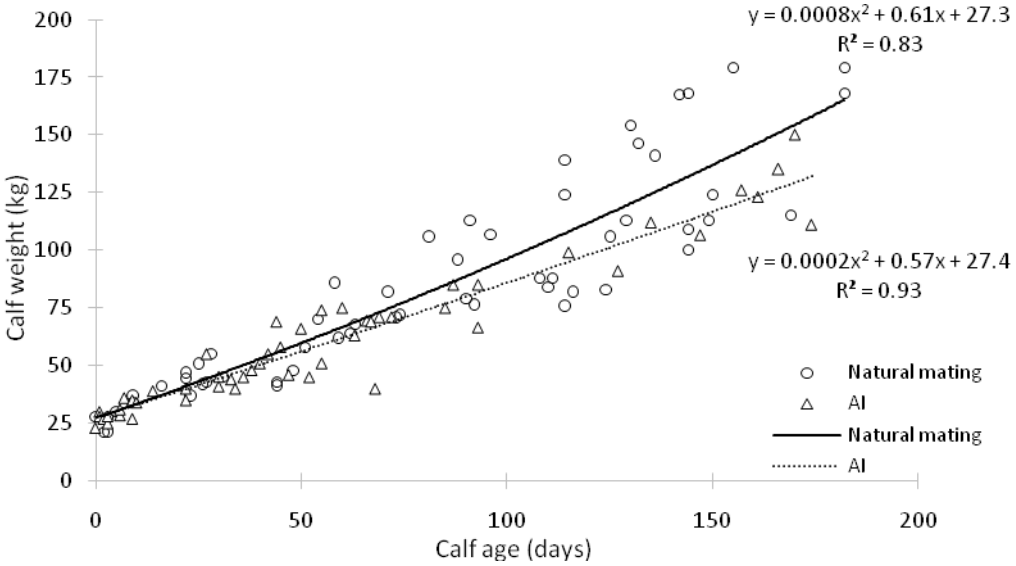

Figure 3.6 Regression analysis of age and weight of 0 to 240 day old calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Mating was by 2 different methods, natural and AI. Each point represents an individual calf. Lines are polynomial regressions.

3.4 Discussion

3.4.1 Cattle production resources

Availability of labour, land, livestock and people in a household can contribute immensely to the success of cattle production in a developing country. Availability of adequate resources for smallholder farmers can be the determining factor for adoption of appropriate alternative technologies for development of a successful livestock industry (Savadogo et al., 1998). These characteristics; include household size, labour, land area, total number of livestock, average cattle per household and grazing time (Parsons et al., 2013; Phung and Koops, 2003). Due to high population density, encroachment of agricultural land, lack of available agricultural and grazing land, and low quantity of native pastures, the livestock husbandry system in Nhon Khanh commune is more suited for intensive production.

3.4.2 Cow-calf management system

The choice of which management tools a farmer adopts can be a good indicator of the level of farming intensity they practice (Parsons et al., 2013). Bathing cattle, vaccination, salt supply, parasite prevention and artificial insemination are strategies applied in Nhon Khanh commune which indicate that smallholder farmers practice intensive farming. However, these techniques are currently more focused on the dam, and not the calf. Nearly 50% of the smallholder farmers utilized artificial insemination and recorded insemination date. However, only 2% of the interviewed smallholder farmers applied early calf weaning in their management practices.

3.4.3 Cow feeding management

Feed resources are becoming markedly depleted due to an increasing population of people and livestock. Therefore it is important to manage the limited feed resources in smallholder households (Stur, 1996). Because of population growth and urbanisation, land for agriculture and grazing is contracting. Therefore efficient feed management technologies are needed in Nhon Khanh commune to deal with the pressure on available feed resources.

The high diversity of potential feed resources and their availability in Nhon Khanh commune depends strongly on the weather and season of cropping. The main feed resources in Nhon Khanh commune are: native grass, cultivated forages, agricultural by-products and concentrate. Areas of native pasture on communal land are small, are devoid of grazing management, have low forage quantity and require high labour inputs for “cut and carry”. Cultivated forages have higher yields and are easier to “cut and carry”. However, there were a lot of difficulties that inhibited the expansion of forages, particularly land limitation and conflicting interests between cropping and use for forage. Rice straw was the most important available and easily stored by-product followed by maize stover and peanut straw. However, the limitation of rice straw is its low quality and high nutrient degradability, especially in the rainy season. Hence, in an intensive system, the use of concentrate feed is becoming increasingly important. Rice bran, maize, peanut cake and cassava powder were the main concentrates in this area. Concentrate supplementation is essential in an intensive cow-calf system because it provides the required nutrients for livestock performance. However, these concentrates are not nutritionally balanced on their own and need to be mixed with others to provide balanced rations. Therefore, different sources of concentrate with adequate nutrients that fits the cow-calf production system are required.

Fluctuation in feed availability is one of the problems causing feed shortages in Nhon Khanh commune, especially between December and January during the rainy season. Heavy rains, low temperatures and reduced solar radiation during this season affect forage growth and grazing time. This is the reason why 50 to 70% of interviewed smallholder farmers faced difficulties in finding enough feed for their cattle during this period. Planting forages or spending time to cut and carry native grass is not a suitable response because of the limitation of private land and bad weather. Therefore, the short term response for dealing with feed shortages by most smallholder farmers was to increase the quantity of agricultural by-products and concentrates fed, which as mentioned earlier, are usually characterised by poor nutrient content and may not be able to support cattle nutrition requirements. The difference in cow BCS at two different times in our survey was evidence for the effect of feed resources on cow performance. Cow

body condition scores in January (typically a period of feed shortage) were lower than in July, for cattle of all physiological phases.

Due to the high number of cattle and limited grazing lands without any grassland management, overgrazing is becoming a big issue in this area. Cattle are often grazed for 3 to 7 h/d on communal land, including the edges of rice fields, river banks and sometimes in the field after harvesting. In general, over-grazing is a major cause of land degradation, soil erosion, and reduction in plant health and productivity (Radácsi, 2005). It leads to low efficiency of utilisation of the grazing system because cattle spend a long grazing time on low quantity and quality native grass. The other problem of over-grazing is that it also keeps grasses very short, so that they are constantly in a phase where they only grow very slowly. Principal component analysis also showed similar results - the more time cows spend for grazing, the longer the CI and the lower BCS they have. These results are supported by Mui (2003) who indicated that the extensive grazing system in Vietnam is limited because of the reduction in grazing areas.

The effect of cooking concentrates on feed intake and digestion is unclear. Cooking of concentrates is a traditional method that is widely practiced in Nhon Khanh commune. However, it costs the households more in terms of labour and energy to cook the concentrate. In addition, high water content of the diet can increase water filling effects in the rumen (Tahir, 2008) and decrease DM intake of cattle. Cows must consume large amounts of feeds to provide the necessary nutrients for their body, especially pre-, and post-partum periods. The amount of cooked concentrate eaten by a cow can give a false indication to a farmer about daily feed intake. Total daily cow DM intake was on average 6.7 kg DM, equivalent to 1.8% of body weight and below the expected feed intake requirement of about 2 to 4% of dairy cow LW(Moran, 2005). Insufficient feed intake will not only affect LW but will also reduce the production level (Tahir, 2008).

3.4.4 Cow performance

Cow body condition score

Pryce et al. (2001) found a strong relationship between BCS and reproduction and they concluded that BCS could be used as a management tool to improve the reproductive

performance of cows. There were several factors that affected cow BCS in Nhon Khanh commune. Firstly, there was variation in cow BCS at different times of the year and BCS was significantly ($P<0.05$) lower in the wet season (January) than in the dry season (July). This difference in BCS was mainly due to availability of feed resources – being relatively lower during the wet season compared to the dry season. The management system also influenced BCS. Factors such as grazing time, number of services per conception and CI were all negatively correlated with cow BCS. The more cows that the famers had, or the more time spent grazing, the lower the cow BCS, likely because the more time spent grazing, the more energy wasted on walking the long distances to and from the grazing field. In addition, the low quality and quantity of the over-grazed native pasture did not compensate for the lost energy. An increase in cow BCS can decrease the number of services per conception and subsequently, CI in beef cows. Also, spending more time grazing can increase heat stress in cattle. The greater the body temperature increase, the more detrimental it is to cattle production (Finch, 1986). This conclusion is supported by McDowell (1972), which showed that growth, lactation and fertility of cows were affected by high body temperature.

Cow fertility

Cow fertility is the major performance indicator of a cow-calf production system. The reproductive performance of cows in Nhon Khanh commune was impressive, as reflected by the low number of services per conception (1.5) and high conception rates at first service (60%). The majority of cows in Nhon Khanh commune were relatively young (parity 3-5) and most smallholder farmers were highly experienced in management skills for managing cow fertility, possibly explaining the impressive reproductive performance of cattle in Nhon Khanh commune. A study by Mukasa-Mugerwa (1989) also indicated that CI is shortest in cows from parities 4-6 (6-9 years old).

3.4.5 Calf performance

The calf is the main product of the cow-calf production system. Therefore, the profitability of this system strongly depends on how fast a calf grows and how quickly it is sold to the market. There were not many noticeable differences in calf weight

performance in the first few weeks. However, the gap in the weight of the calves began to expand thereafter until 250 days of age. This might be because after 50 days, the dam's milk yield is unable to supply enough nutrition to support rapid calf growth, and therefore other feed resources are responsible for meeting nutrient requirements. This result was supported by Greenwood and Cafe (2007) who reported that pre-weaning calf growth was strongly affected by lactation performance of the dam and quality of other feed resources.

There was a significant difference in calf growth performance between calves from natural mating and AI. Calves born by natural mating grew faster, especially after 100 days, compared with calves from AI. This might be because the crossbred calves (*Bos indicus x Bos taurus*) mainly out of AI matings require more nutrition for growth, development and maintenance than calves from bulls have a greater proportion of yellow (local) genetics. However, the lactation performance of *Bos indicus* cattle is poor and often not sufficient to supply enough nutrients to support adequate calf growth (Cunningham and Syrstad, 1987). Moreover, there was evidence of apparent lack of experience in calf feeding management because the smallholder farmers usually focused more on cows. This slowed down the calf's ability to nibble at pasture early and consume large quantity of concentrates, thus leading to a decrease in overall feed dry matter intake. In addition, the results from our survey showed that smallholder farmers who predominantly graze their cattle tend to use AI. This could explain why AI calves tend to grow more slowly, because of the inefficient feeding system that they are exposed to.

There were several factors affecting calf pricing. Subjective visual assessment of physical body conformation plays an important role in the negotiation of calf price. The main reason is smallholder farmers do not have any tools to help them negotiate calves prices. We found a strong relationship ($r^2 = 0.95$) between calf weight and chest girth. A measurement tool could be developed to estimate calf weight based on measured calf chest girth, and could easily be used by smallholder farmers.

3.5 Conclusions

A key to successful intensive cow-calf production systems is the adoption of appropriate feeding technologies that extend farm-grown forage area and suitable concentrate supplementation strategies that provide adequate feeds and nutrients for cattle throughout the year to ensure cows are maintained in acceptable body condition. This will improve the growth rate of calves and their ability to reach specific market weight targets, and also possibly improve cow productive and reproductive performances. Therefore, a better understanding of the cow-calf production system is necessary for developing management and nutritional strategies for cow-calf production in South Central Coastal Vietnam.

Feed shortage is still the biggest constraint in Nhon Khanh commune. Being such a small agricultural area, the commune highly depends on seasonal cropping and the dictates of unpredictable and fluctuating weather conditions that affect the availability and preservation of feed resources. Over-grazing is an additional issue. There was clear evidence from our study that grazing time was closely correlated with cow BCS and CI. Concentrates were used by almost all the smallholder farmers surveyed. However, the traditional feeding method may reduce the efficiency of supplementation. It was also evident that the most important factor affecting calf price is calf subjective visual assessment. A well performing calf will require a well-balanced diet to attain the required body condition and daily gain to improve its growth performance.

From the discussed characterisation data of the cow-calf production system in Nhon Khanh commune, future research should focus on:

- Traditional cattle feed resources (both roughages and concentrates) are inadequate to meet nutrient requirements for lactation in cows and for calf growth. Therefore, research on suitable supplements in the cow-calf diet should be a priority. An improved diet should be of high quality nutrients, readily available and economically affordable.
- Research on pre- and post-partum nutrient requirements of cows with a view to understanding the critical points for intervention. This will help producers to make

informed choices on the best intervention time for the right physiological phase to supplement in order to achieve the highest and most efficient cow-calf outcomes.

- The lack of experience in calf management can result in decreased calf growth rates, due to inadequate feeding. Therefore, there is a need for implementing early weaning to improve calf performance. In addition, it is also important to understand the nutrition requirements of calf pre- and post-weaning in order to achieve the weaning weight quicker.

In addition, calf prices were usually negotiated depending on subjective visual assessment and, therefore, the price can be unpredictable. Hence, in order maintain more predictable and stable prices, a calf weight estimation tool, which could be easily used by smallholder farmers, should be developed.

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Chapter 4 On-farm cow-calf performance in response to pre- and post-partum concentrate supplementation in South Central Coastal Vietnam

Abstract

Supplementing cows with concentrate feeds in the last trimester of pregnancy and during lactation is important in maintaining cow body condition, positive energy balance and preventing the mobilisation of stored fat. However, there is a lack of information about the effect of supplementary feeding of beef cows during pre and post-partum periods on cow-calf performance in South Central Coastal Vietnam. Therefore, the main objective of this study was to evaluate the effect of pre- and post-partum supplementary feeding on cow-calf performance in an on-farm experiment.

Twenty crossbred cows (initial average LW of 366 ± 53 kg and parity ≤5) in the third trimester of pregnancy were randomly allocated into four pre- and post-partum treatment groups comprising: 1) Control diet only; 2) Control diet pre-partum and improved diet post-partum; 3) Improved diet pre-partum and control diet post- partum; and 4) Improved diet pre- and post-partum. All treatment groups were fed a basal diet of 30% King grass and 70% rice straw at 2% of their bodyweight on a DM basis. The quantity of basal diet was adjusted monthly in accordance with changes in LW. The control diet was a mixture of maize powder (50%) and rice bran (49.5%) offered at 0.25% of body weight (BW) pre-partum and 0.35% of BW post-partum. The improved diet was a mixture of maize powder (20%), rice bran (20%), peanut cake (20%) cassava powder (39%), and urea (1%) offered at 0.35% of BW pre-partum and 0.5% of BW post-partum. Both dietsalso included 0.5% mineral premix. Feeding of the improved diet had a significant ($P<0.05$) positive effect on calf weight, body length, and chest girth at birth, but not ($P>0.05$) at 90 days. There was a significant effect of diet on average cow body weight, body condition score (BCS) and calving to conception interval (CCI). However, the timing of feeding the concentrate (pre- or post-partum) had no effect. The CCI was longer for cows fed the

control diet (212 days) than for cows supplemented pre-partum (176 days). Cows supplemented post-partum had the shortest CCI (144.5 days). In conclusion, post-partum supplementation improved cow-calf performance and induced early cyclicity, thereby shortening the interval from calving to conception and overall reproductive performance under on-farm conditions.

Keywords: Concentrate, cow-calf performance, on-farm, supplementary feeding, Vietnam.

4.1 Introduction

Agriculture is the dominant source of livelihood for 47% of Vietnam's 90 million people(GSO, 2014). In Vietnam, livestock are an important income generator for smallholder farmers; more than 90% of the national cattle herd are raised by smallholders. Only 20% of the land area of Vietnam is within the lowland or coastal zone, but these areas support most of the population for food and livestock production. Improved cattle production is important for increasing and diversifying farm income sources (Leddin et al., 2011).

In South Central Coastal Vietnam, the basal diet of cattle is generally grazed native grass, cultivated forages, and agricultural by-products (Ba, N et al., 2005). This basal diet is characterised by low crude protein and fermentable carbohydrates. In addition, the roughage resources are dependent on prevailing seasonal and weather fluctuations. In the dry season, cattle are unable to meet their nutritional requirements for growth and lactation because the forages are not only scarce, but also of low quality. Waterlogging, which is very common during the rainy season, affects the availability of roughage resources. Concentrates such as rice, rice bran, cassava powder, and peanut cake are used as supplements. However, with the high price of purchased feed ingredients, farmers only partially supplement their cattle, with small quantities, particularly during times of feed shortage, pregnancy, or lactation. The low quality grasses and other feedstuffs available to smallholder households are inadequate in meeting the nutritional requirements of livestock.

In cow-calf production systems, fertility is a major driver of profitability. Economic losses can be due to poor fertility, particularly long CI(Van Arendonk et al., 1989). Nutrition has a positive effect on production (McDonald et al. 2002), body condition score (BCS), lactation yield and peak lactation of the cow, and the development of both foetus and calf (Hersom, 2010; NRC, 2000). Cows require higher energy and protein levels for maintenance and development of the foetus during pregnancy. Protein requirement becomes significant only in the last few months of pregnancy (Moran, 2005) as two thirds of the foetal growth occurs during the last two months of gestation(Hersom, 2010). Adequate protein status pre-partum is also essential for the production of high quality colostrum, which is important for newborn calf health (Hersom, 2010). Energy stores during the last trimester of pregnancy, calving and early lactation affect the length of the post-partum anoestrus interval and probability of successful conception (Chagas et al., 2007). Inadequate nutrition of cows in the last three months of pregnancy might affect the calves by causing death in-utero or by decreasing birth weight (McDonald et al. 2002). Underfeeding during late pregnancy can also increase CI (Ferrell, 1991; Short et al., 1990), lower milk production and decrease calf weight at weaning(Bellows and Short, 1978; Corah et al., 1975). Therefore, inadequate nutrients over a long period can result in low cow fertility, poor reproductive performance, and poor body condition of calves.

Concentrates are essential in cow-calf production systems for correcting nutritional deficiencies and ensuring balanced diets. Supplements with high protein contents can help Zebu cattle improve their reproductive efficiency (Robinson, 1990). In a study by Galina and Arthur (1989), cow reproductive performance was improved by supplementing 8 weeks before calving to 8 weeks after calving. In contrast, Soto et al. (2001) found that the level of supplementation offered before and/or after calving did not improve pregnancy rate.

Body condition score is used as a subjective method to determine body fat reserves of sheep, beef, and dairy cattle (Lowman et al., 1973). The method is based on a visual and tactile appraisal of body fat reserves in the back pelvic regions and is usually scored on a scale of 1 to 5. The method became popular because it is an accepted, quick, and cheap method of gauging the nutritional status of cattle (Popescu et al., 2009; Waltner et al.,

1993). Pryce et al. (2001) concluded that BCS could be used as a management and selection tool to improve reproductive performance because of the strong relationship between BCS and reproduction. Several studies with dairy cows have detailed the relationship between BCS and fertility (Gillund et al., 2001; Roche et al., 2007), but the results are conflicting. Some studies confirm thepositive relationship between reproduction and pre-partum body condition (Mouffok et al., 2013; Singh et al., 2009) and post-partum body condition (Patton et al., 2007). Others reported that body condition only affects milk production (Walter, 1993). In addition, BCS can be used as a selection index to improve fertility, because BCS has a higher heritability (0.2 to 0.3) (Jones et al., 1999) than CI, days to first service, and conception rate (typically less than 0.1) (Hoekstra et al., 1994).

In Vietnam, most of the ruminant nutrition studies have concentrated on beef bulls or dairy cows and very little on beef cows. There is a dearth of information about the effect of supplementing beef cows during the pre- and post-partum periods on cow-calf performance under on-farm management conditions in Vietnam. A full understanding of the nutritional requirements of cows during pre- and post-partum periods and response to dietary supplementation will have a significant impact on improving cow-calf reproduction systems, especially for smallholder households.

Therefore, the primary objective of this study was to evaluate the impact of supplementing cows with concentrate 3 months prior to, and after calving, on cow-calf productivity in South Central Coastal Vietnam. The hypotheses tested were: i) adequate cow nutrition in the last 3 months of pre-partum gestation will improve cow BCS and LW, ii) adequate cow nutrition in the last 3 months pre-partum willincrease the LW of newborn calves, and iii) adequate cow nutrition in the 3 months either pre-partum or post-partum can improve cow reproductive performance and reduce the CI.

4.2 Materials and Methods

All experimental procedures were in accordance with the University of Tasmania Animal Ethics Committee guidelines, the 1993 Tasmania Animal welfare Act, and the 2013 Australian Code of Practice for the Care and Use of Animals for Scientific Purposes. The animal ethics application (A13695) was approved by University of Tasmania Animal Ethics Committee on 13 December 2013.

4.2.1 Location of experimental site

The study was conducted in Nhon Khanh Commune, Binh Dinh Province, South Central Coastal Vietnam (between 14°10′N and 109°0′E). The region was chosen because the existing crop-livestock system is typical for Central Vietnam. In addition, Nhon Khanh has had a well-developed cow-calf system and has become an important calf market in Binh Dinh Province.

4.2.2 Animals, experimental design and treatment groups

Twenty crossbred cows (initial LW of 366 ± 53 kg and parity ≤5) in their last trimester of pregnancy were sourced from local farms in Nhon Khanh Commune and this experiment was conducted on-farm. Cows were randomly allocated into four pre- and post-partum treatment groups comprising: 1) Control diet only; 2) Control diet pre-partum and improved diet post-partum; 3) Improved diet pre-partum and control diet post-partum; and 4) Improved diet pre- and post-partum. Cows were also randomly assigned into five cohorts (blocks) with approximately 15-day intervals between pregnancies.

The experimental design is shown in Table 4.1.

Table 4.1 Design of pre- and post-partum treatments for feeding control and improved diets to crossbred beef cows in Binh Dinh, Vietnam

Treatment	Pre-partum	Post- partum
Pre - Post -	Control diet	Control diet
Pre + Post -	Control diet	Improved diet
Pre - Post +	Improved diet	Control diet
Pre + Post +	Improved diet	Improved diet

All cows were fed a basal diet of 30% King Grass and 70% rice straw at 2% of their bodyweight. The control diet included supplement offered at 0.25% of cow body weight before calving and 0.35% after calving. The improved diet included concentrate supplements offered at 0.35% of cow body weight before calving and 0.5% after calving. The Control diet was formulated to represent the typical feeds used for cows in Nhon Khanh commune and comprised a mixof 50% maize meal, 49.5% rice bran, and 0.5% mineral premix. The improved diet contained 39% cassava powder, 20% maize meal, 20% rice bran, 20% peanut cake, 0.5% urea, and 0.5% mineral premix. The prices of the control and improved diets were $0.45 and $0.44 (AUD) per kg, respectively (Table 4.2).

Table 4.2 Ingredient composition of the diets and their prices.

Ingredient	Proportion (%)		Price (VND/kg)
	Control diet	Improved diet	
Maize meal	50	20	7500
Rice bran	49.5	20	7000
Cassava meal	-	39	5500
Peanut cake	-	20	10000
Urea	-	0.5	5000
Premix	0.5	0.5	50000
Price (VND/kg)	7472	7320	

(1$ AUD = 16.500 VND)

The nutrient compositions of the roughage, supplement ingredients and supplementary rations are shown in Table 4.3.

Table 4.3 The nutrient composition (% on DM basis) of the basal and supplementary diets

Feed source	DM (%)	CP (% DM)	EE (% DM)	Ash (% DM)	NDF (% DM)	ADF (% DM)
Rice straw	89.1	3.8	1.2	12.5	62.6	37.8
King grass	18.2	11.3	2.2	10.8	54.5	29.2
Maize	93.5	8.6	4.2	1.5	13.0	4.1
Cassava meal	91.0	2.9	0.6	2.3	8.4	4.3
Rice bran	92.8	11.5	14.4	6.9	20.2	7.7
Peanut cake	94.0	49.4	8.0	5.0	10.8	7.0
Control diet	93.2	9.8	8.9	4.6	18.0	5.9
Improved diet	92.4	15.6	5.0	3.9	15.4	5.6

DM=dry matter, CP=crude protein, EE=ether extract, Ash= mineral, NDF=neutral detergent fibre, ADF=acid detergent fibre.

4.2.3 Sampling procedures and measurements

4.2.3.1 Feeding and feed residuals

The experimental supplements were prepared monthly. The experimental animals were given a 7-day adaptation period. Basal feed intakes were determined on 3 continuous days fortnightly and supplement intakes were recorded daily throughout the study period. Feed residuals were weighed and recorded the following morning before allocating the next day's rations. All cows were offered supplements in three equal portions at 0700 h, 1300 h, and 1800 h each day. Cows were grazed for 5 h/d (2 h in the morning and 3 h in the afternoon). The amount of supplement was adjusted monthly based on cow LW. All experimental animals had *ad libitum* access to drinking water at all times.

4.2.3.2 Cow liveweight, cow fertility status and body condition score

Cow LW was measured monthly using a weighing scale (FX 15 Iconix). Body condition score was estimated on a 5-point scale (1 = severe under-condition, 2 = under-condition, 3 = good condition, 4 = over-condition, 5 = severe over-condition) with increments of 0.25 (Wildman et al., 1982). Individual animals were assessed at the start of the experiment and monthly throughout the duration of the experiment (24 weeks). After

calving, cow fertility traits of calving to first service interval (CFSI), calving to conception interval (CCI), and number of services per conception were recorded.

All new-born calves were immediately weighed, tagged, and body length and chest girth measurements taken. Measurements were recorded for every calf fortnightly until the attainment of 3 months of age.

4.2.4 Chemical analysis of samples

Nutritive value of the supplement ingredients and experimental diets was determined as follows: Samples were dried to a constant temperature at 60.5 ^{o}C in a fan forced oven for 48 h. The DM was computed as the difference between the initial and final weights of samples. Ash content was determined by combusting samples in a furnace (Nabertherm, Germany) at 600 ^{o}C for 8 h (AOAC Official Method 942.05)(AOAC, 1990). Neutral (NDF) and acid (ADF) detergent fibre concentrations were measured by Kjeltec ^{TM} 1020 (Foss, Sweden) using a modified Van Soest method (Goering and Van Soest, 1970) and modified AOAC Official Method 973.18, respectively. Nitrogen was determined using the Kjeldahl method (AOAC method code no. 988.05) (AOAC, 1990) and the values multiplied by 6.25 to estimate crude protein (CP). Ether extract (EE) was determined using AOAC Official Method 920.39 (Soxtec ^{TM}2055, Foss, Sweden).

4.2.5 Statistical analysis

Data analysis was performed using mixed models procedure in SAS version 9.4 (SAS, 2014) with the denominator degrees of freedom approximated using the Satterthwaite method. Diet and time were fixed factors, and cohort (block) was a random factor. For analyses over time, the REPEATED statement was used, with animal (diet) as the subject, using an autoregressive (AR1) covariance structure. Tukey's test was used to test differences ($P<0.05$) among means where the overall F test was significant.

4.3 Results

4.3.1 Performance of cows pre- and post-partum

There were significant effects of diet ($p<0.001$) on cow LW and BCS, but no significant interaction between diet and pre- and post-partum supplementation for either response variable.

The cows fed the control diet had an average (across the duration of the experiment) LW of 341 kg and an average BCS of 3.15 ($P<0.0001$), which is lower than cows in other treatments (Av. 369 kg, BCS 3.34) (Table 4.4). The final average LW and BCS of cows fed the control diet were also lower ($P<0.001$) than cows in other treatments, although there were no differences at calving ($P>0.05$) (Table 4.4). The LW and BCS of cows at calving, averaged across all treatments, were 355 kg and 3.40, respectively.

There were no differences ($P>0.05$) between supplementing pre-partum or post-partum in weight or BCS responses (Table 4.4). There was also no effect of double supplementation (pre- and post-partum) compared with a single supplementation (pre- or post-partum) (Table 4.4).

Table 4.4 Least squares means and standard errors (SE) of liveweight (LW), body condition score (BCS), calving to first service interval (CFSI), and calving to conception interval (CCI) of crossbred Vietnamese cows.

Supplementation treatment	Least Squares Means							
	Average[2] LW (kg)	LW at calving (kg)	Final LW (kg)	Average[2] BCS[1]	BCS[1] at calving	Final BCS[1]	CFSI (days)	CCI (days)
Pre - Post -	341 ± 5 [a]	338 ± 6 [a]	322 ± 9 [a]	3.2 ± 0.04 [a]	3.3 ± 0.06 [a]	2.8 ± 0.08 [a]	206 ± 26 [a]	212 ± 24 [a]
Pre + Post -	372 ±5 [b]	363 ± 6 [a]	362 ± 8 [b]	3.3 ± 0.04 [b]	3.4 ± 0.06 [a]	3.2 ± 0.08 [b]	174 ± 26 [b]	176 ± 24 [b]
Pre - Post +	372 ± 5 [b]	360 ± 6 [a]	358 ± 8 [b]	3.3 ± 0.04 [b]	3.5 ± 0.06 [a]	3.2 ± 0.08 [b]	130 ± 26 [c]	147 ± 24 [c]
Pre + Post +	365 ±5 [b]	363 ± 6 [a]	350 ± 8 [ab]	3.4 ± 0.04 [b]	3.5 ± 0.06 [a]	3.2 ± 0.08 [b]	138 ± 26 [c]	142 ± 24 [c]
Significant difference	20.9	26.2	33.6	0.15	0.26	0.31	24.8	27.5

[a-b-c] In each column, least squares means without a common superscript are significantly different (P<0.05) according to Tukey's test.
[1] Scale 1-5 (Wildman et al., 1982)
[2] Average LW or BCS, from 3 months pre-partum to 3 months post-partum

There was a highly significant ($p<0.001$) effect of diet on CFSI and CCI. CCI was longer for cows fed the control diet (212 d) than for cows supplemented pre-partum (176 d) (Table 4.4). Cows fed post-partum had an even shorter CCI (Av. 144.5 d). There was no difference between double supplementation and post-partum supplementation (Table 4.4). The results for CFSI followed the same trends as for CCI.

Trends in LW (Figure 4.1) and BCS (Figure 4.2) variations over the experimental period reflect the increase in LW and BCS of the cows during the latter stages of pregnancy, a drop in LW at calving, and a continued decline in LW and BCS during early lactation, as would be expected.

All cows gained weight from the initial weight at day -90 to day -30 in all treatment groups. The rate of weight gain as a reflection of foetal growth, was lower ($P<0.05$) in the control group than all other treatments. At calving, LW in all treatments fell and continued through to +90 days after calving with a sharper gradient in the control group ($P<0.05$) than all the other treatments.

The BCS trend in cows for the whole experimental period is shown in Figure 4.2. Body condition score increased sharply during the last 3 months of pregnancy in all cows. At calving, the average BCS was 3.4. After calving, the BCS slightly declined in the 3 months post-partum to 3.2, except for cows fed the control diet whose BCS declined dramatically after calving to 2.8 at +90 days post-partum.

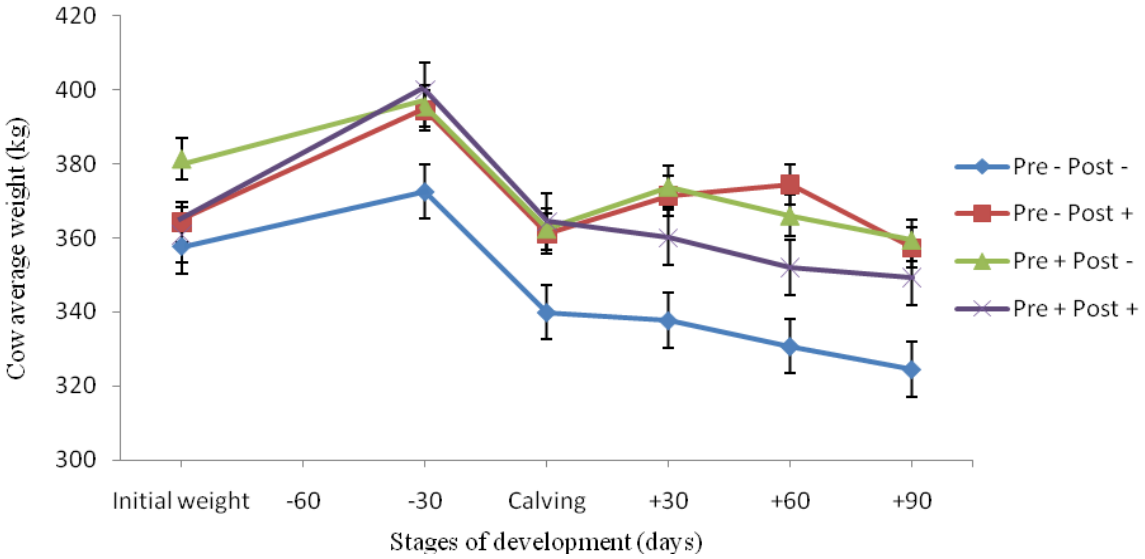

Figure 4.1 Trends in liveweight variation in response to pre- and post-partum supplementation of cows. Points are LS Means, except for initial weight, which are unadjusted means. Error bars ± SE

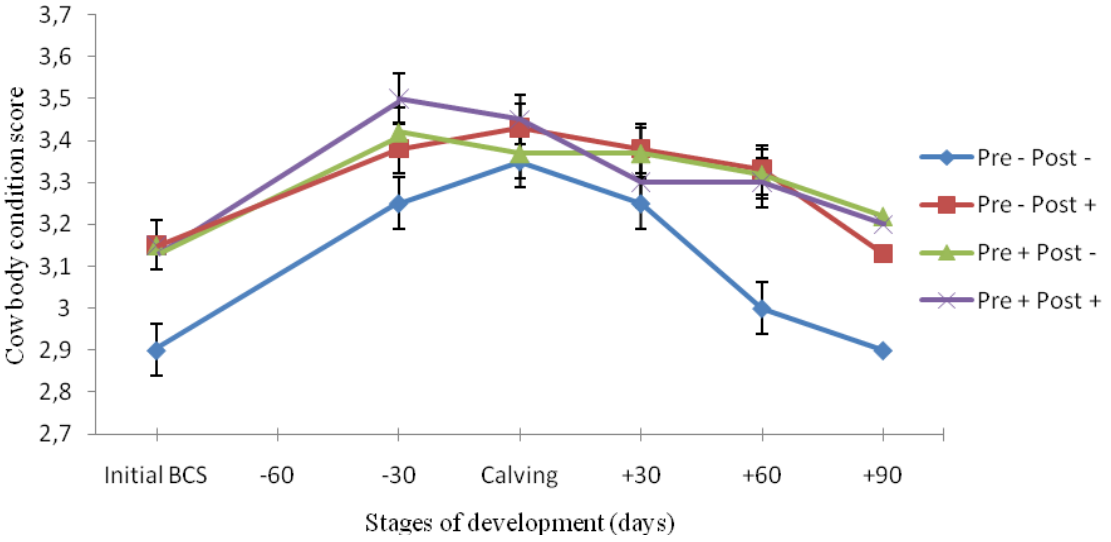

Figure 4.2 Trends in BCS variation in response to pre- and post-partum supplementation of cows. Points are LS Means, except for initial BCS, which are unadjusted means. Error bars ± SE

4.3.2 Performance of calves from calving to 90 days post-partum

The effect of pre-partum supplementation on new-born calf performance is shown in Table 4.5. Supplementing with the improved diet in the last trimester of pregnancy resulted in bigger calves ($p<0.05$) at calving. New-born calves from cows fed the improved diet weighed an average of 28.8 kg, compared with 27.0 kg in the control group. The average new-born calf body length and chest girth were significantly smaller for the control (46.9 cm and 67.8 cm) than improved (52.6 cm, 71.1 cm) dietary groups.

Least squares means of weight, body length, and chest girth of calves from calving to 90 d post-partum, and at 90 d are shown in Table 4.6. There was no effect ($P>0.05$) of diet on average calf weight, body length, or chest girth from calving until 90 d post-partum. There was a significant interaction between diet and time on calf body length; however there is no clear trend in the data. The significant effect ($P<0.05$) of time simply reflects that the calves increased in weight and size over time.

A static analysis at day 90 (Table 4.6) also confirmed no impact of the diets on average calf weight, body length, or chest girth. At day 90, the average weight of calves was 100 kg, with an average body length of 78 cm and chest girth of 106 cm (Figure 4.3). These results show that although there was an effect of pre-partum supplementation of cows on the size of new-born calves, by 90 d the effect was no longer detectable.

Table 4.5 Least squares means and standard errors (SE) of liveweight (LW), body length, and chest girth of newborn calves born to cows offered control or improved diets pre-partum.

Supplementation treatment	Least Squares Means		
	Calf LW (kg)	Calf body length (cm)	Calf chest girth (cm)
Control diet	27.0 ± 0.9	46.9 ± 1.1	67.8 ± 1.1
Improve diet	28.8 ± 0.9	52.6 ± 1.1	71.1 ± 1.1
P-value	0.047	0.003	0.010

Table 4.6 Least squares means of liveweight (LW), body length, and chest girth of calves from calving to 90 days post-partum, and at 90 days born to cows offered control or improved diets pre-partum and post-partum.

Treatment	LW (kg)	Body length (cm)	Chest girth (cm)
Calving to 90 days post-partum			
Pre - Post -	64.6 ± 3.2	65.9 ± 1.5	89.3 ± 0.9
Pre + Post -	65.0 ± 3.1	65.4 ± 1.4	90.9 ± 0.9
Pre - Post +	63.0 ± 3.2	65.6 ± 1.4	89.9 ± 1.0
Pre + Post +	63.5 ± 3.1	64.6 ± 1.4	90.6 ± 1.0
Sig. difference [1]	13.4	5.9	3.2
90 days post-partum			
Pre - Post -	100.5 ± 4.3	80.2 ± 2.7	106 ± 0.6
Pre + Post -	102.3 ± 4.3	78.4 ± 2.6	107.5 ± 0.6
Pre - Post +	97.7 ± 4.3	77.2 ± 2.5	106.1 ± 0.6
Pre + Post +	97.8 ± 4.3	74.4 ± 2.6	105.4 ± 0.6
Sig. difference	17	10.6	2.3

[1] Minimum significant difference (P<0.05) between means, according to Tukey's test.

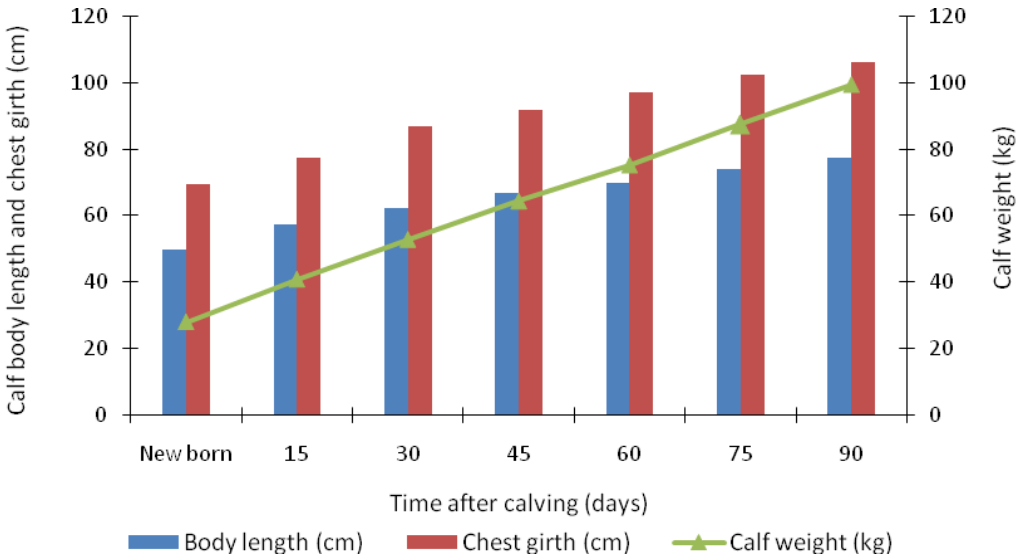

Figure 4.3 Average body weight, body length, and chest girth change of calves from calves to 90 days post-partum. Points are LS Means.

4.4 Discussion

4.4.1 Cow body weight, body condition and reproductive performance

Cows fed an improved diet on average had heavier body weights and higher BCS compared with cows fed the control diet. All experimental cows were in very good condition (3.40) at calving, close to the score of 3.50 recommended by Van Saun (1991). In addition, no cows had a BCS greater than 3.75, which would indicate over-condition (Gearhart et al., 1990). In high producing Holstein dairy cows, the calving BCS associated with the greatest milk production is 3.5 on a 5-point scale system (Roche et al., 2007; Waltner et al., 1993b). At day 90 after calving, the BCS of control diet cows had dropped to 2.8and was significantly lower than BCS of cows in other groups which had an average score of 3.20. This is likely because the control diet could not provide sufficient nutrition to meet nutrient requirements after calving, so the cows mobilised fat reserves to support milk production. Although there was an effect of double supplementation, this was largely because of the strong effect of post-partum supplementation, as there was no difference between double supplementation and post-partum supplementation. To sum up, supplementing with improved diets pre- and/or post-partum improved final cow weight and BCS.

This research also found a significant effect of diet on reproductive performance of cows. Post-partum supplementation reduced the duration of calving to conception interval. This contrasts with the results of Soto et al. (2001), who found that pre- and/or post-partum supplementation did not improve reproductive performance, although there was a trend towards improvement. The reason for differences in results could be that the experiment of Soto et al. (2001) was conducted for a shorter period (45 rather than 90 days of supplementation), grazing Stargrass (*Cynodon nlemfuenis*) pasture only, and with a lower amount of concentrate (0.35% rather than 0.5% of body weight after calving) than in this study; thus the treatments did not have an effect. The long CI observed in cows on the control diet in this experiment is consistent with previous research of McDonald (2002), who found that there can be a detrimental

effect on reproductive performance if a cow is suffering from severe under-nutrition during her last trimester of pregnancy.

4.4.2 Calf performance

There was a significant effect of diet on calf birth weight, body length, and chest girth. Calves from cows on the improved diets were on average 1.8 kg heavier than their counterparts from the control diet group. This supports our hypothesis that adequate cow nutrition in the last 3 months pre-partum gestation can improve the LW of newborn calves. The effects of pre-partum supplementation on calf performance are in general agreement with the findings of many researchers. Hight (1966) found a significant effect of pre-partum nutrition on calf-birth weight. Some studies found no significant effect of pre-partum supplementation on calf-birth weight, but cows that were on a low level of nutrition produced slightly lighter and smaller calves than those on a high nutrition level (Corah et al., 1975; Anderson et al., 1981;Soto et al., 2001; Khan et al., 2002;). This might be due to the fact that offering an improved diet provided a more balanced diet to pregnant cows, so cows can supply more nutrition for the developing foetus. In our experiment there was no significant impact of diet on calf size or weight at 90 days. These results are in agreement with the findings of other researchers who observed that there was no effect of pre-partum supplementation on calf growth rate from calving to four months of age (Khan et al., 2002). Soto et al. (2001) reported that supplementing cows pre- and post-partum did not affect calf weaning weight. This is likely because the low milk yield of zebu cattle is often not sufficient to supply enough nutrients to support adequate calf growth (Cunningham and Syrstad, 1987), and a substitution effect of nibbling at pasture and concentrates takes over from sole reliance on milk.

4.4.3 Costs versus benefits

The total cost of offering concentrate post-partum was approximately $80 (AUD) per cow on the control diet, compared with $105 on the improved diet. The improved diet post-partum reduced the CCI from 212 days with the control diet to 147 days, thus shortening the CI from 16.4 months to 14 months (with an average gestation period of

280 days). If the minimum feed cost (concentrate plus roughage) is approximately $1 per day, the reduction in CI can reduce the feeding cost by at least $60 to $70 per calf cycle.

In a cow-calf system, if the days to calving are decreased, a farmer can not only save on feed costs, but also on labour. More importantly, the reduction in CI to 12 months facilitates improved cow-calf management by controlling mating time, storage of feed reserves, and early attainment of market weight by the calf. Furthermore, a yearly cycle allows farmers to choose the ideal calving season to avoid shortage of grazing areas, forage supply, or deleterious and harsh weather conditions.

4.5 Conclusion

In this experiment, the improved diet is suitable as a supplementary source of nutrients for crossbred beef cows in South Central Coastal Vietnam. Supplementation with an improved diet pre- or post- partum had positive effects on cow weight, BCS, and fertility, as well as the weight and size of calves at parturition compared with the control diet. In addition, supplementation with an improved diet post-partum can help to reduce the calving to conception interval by 60-70 days compared with cows on the control diet. Cows offered an improved diet post-partum did not show any difference in average weight, BCS, or reproductive performance compared with cows supplemented pre- and post-partum.

Considering these results, we suggest that an improved diet could be used to supply crossbred cows from calving until 3 months post-partum to improve cow reproductive performance and increase the profitability of the cow-calf production system in smallholder households in South Central Coastal Vietnam. From an economic and overall cow-calf performance points of view, post-partum feeding is the most viable option for the concentrates utilised in this study under the typical Vietnamese production system.

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Chapter 5 General summary and conclusion

The current characteristics of the cow-calf system in Nhon Khanh presented in Chapter 3 demonstrated that intensive production is likely to be more suitable for cow-calf operations than extensive system in SSC Vietnam. Feed shortages during the rainy season are the biggest constraint in such systems. The clear evidence from the survey was that the current grazing system is not an efficient method for producing calves. Households implementing a stall-feeding system applied management techniques such as vaccination, parasite prevention, and vitamin and mineral supplementation more widely than grazing system households. However, these techniques are more focused on the cow, and not the calf. It was also evident that the most important factor affecting calf price is the subjective visual assessment of physical body conformation by the trader. In this case the price of calves strongly depends on the subjective evaluation of the traders, implying that farmers had to sell the calves for less than their real value.

Cow performance and fertility responses to improved diets were presented in Chapter 4. It was apparent that supplementation with an improved diet pre- or post- partum had positive effects on cow LW, BCS and fertility, compared with the control diet. In addition, post-partum supplementation with an improved diet helped to reduce the calving to conception interval by 60-70 days compared with cows on the control diet, which could reduce the feeding cost by at least $60 to $70 per calf cycle. There was no additional benefit of feeding pre-partum in addition to post-partum.

Supplementation with an improved diet pre-partum had positive effects on LW and size of calves at parturition. This supports the hypothesis that adequate cow nutrition in the last 3 months pre-partum can improve the LW of newborn calves. This might be due to the fact that offering an improved diet provided a more balanced nutrient supply to both pregnant cows and the developing foetus. However, there was no significant impact of diet on calf LW, body length and chest girth at 90 days post-partum.

In conclusion, this thesis has demonstrated that using local feed resources to match the right physiological status of the cow can be of strategic and tactical supplementation

significance in improving reproductive performance, calf survival and reducing feed and labour costs. Furthermore, the improved diet had significant positive effects on cow-calf fertility and performance. Together, these results suggest that an improved diet could be used to increase the profitability of the cow-calf production system in smallholder households in South Central Coastal Vietnam.

From economic and overall cow-calf performance points of view, a combination of supplementation with improved diets post-partum is viable operational options for supplementation with the concentrates utilised in this study without any detrimental impact of dystocia.

This research found a strong impact of post-partum supplementation on cow performance. Therefore, for further research, it is suggested that the effect of post-partum supplementation utilising different levels of protein for calf growth and energy for lactation to simultaneously enhance cow-calf performance would be of strategic significance. Further research could focus on the impact of using different local concentrate sources as supplements for enhancing cow-calf performance.

Chapter 6 Appendix

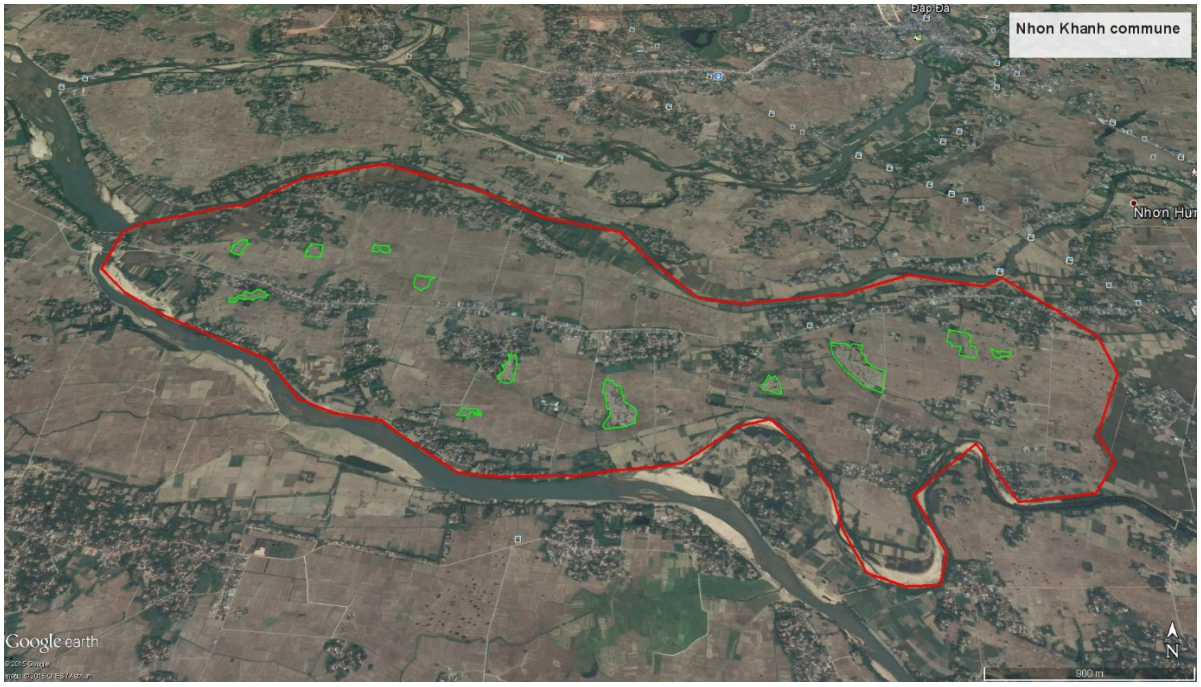

Plate 6.1Nhon Khanh commune (within the red line) and the communal grazing land (within the green lines), Binh Dinh Province, South Central Coastal Vietnam

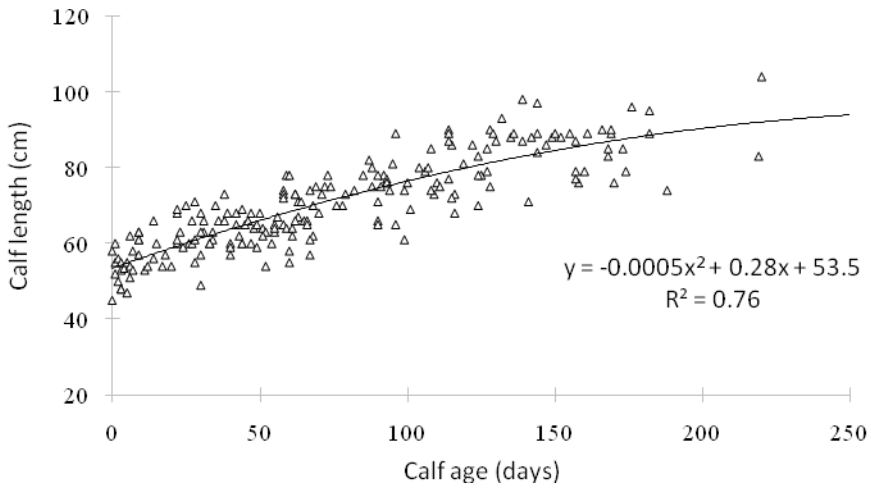

Figure 6.1Regression analysis of age and calf length (of 0 to 240 day old calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Each point represents an individual calf. Lines are polynomial regressions.

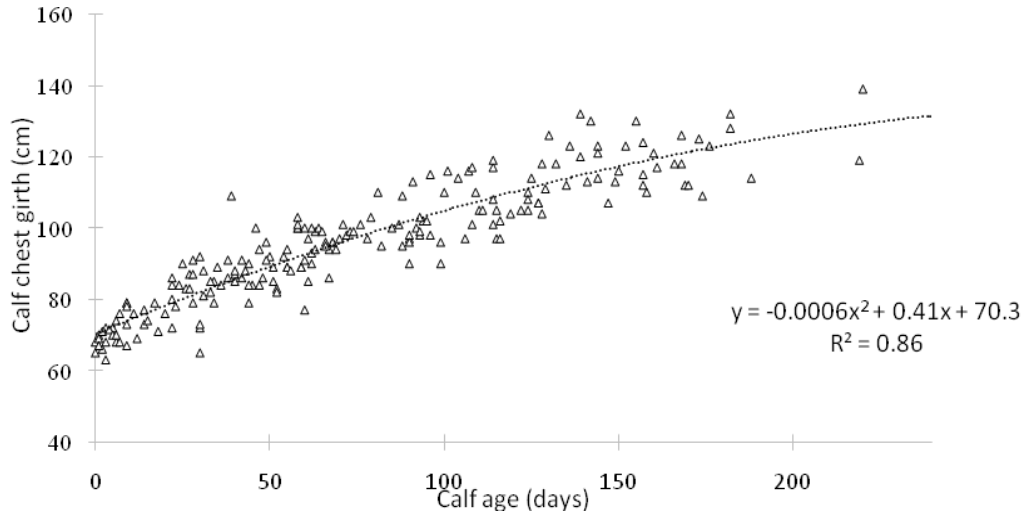

Figure 6.2 Regression analysis of age and chest girth of 0 to 240 day old calves in Nhon Khanh commune, Binh Dinh province, South Central Coastal Vietnam. Each point represents an individual calf. Lines are polynomial regressions.

Table 6.1 Composition and nutritive value of the common cattle feeds in SCC Vietnam

No.	Name of feeds	DM (%)	CP (%)	CF (%)	NFE (%)	Ash (%)	ME (Kcal)
1	Natural grass	24.1	2.6	6.9	11.6	2.3	528
2	Brachiaria mutica	19.1	1.8	5.1	9.8	1.9	420
3	Para grass	24.4	2.6	7.1	11.9	2.4	527
4	Water Spinach	11.5	2.6	1.7	4.7	1.8	279
5	Maize stover (fresh)	54.9	0.9	15.7	33.8	3.1	1100
6	Elephant grass (at 30 days)	15.8	3.2	4.7	5.4	1.9	353
7	Rice straw	86.3	4.9	29.8	36.0	13.6	1426
8	Peanut straw (fresh)	28.8	5.1	5.2	14.0	3.6	689
9	Cassava straw (fresh)	19.5	3.9	4.7	7.2	2.3	463
10	Peanut straw (dried)	90.9	11.4	30.3	34.7	10.9	1791
11	Maize stover (dried)	88.8	6.0	28.7	46.2	6.3	1711
12	Cassava straw (dried)	79.1	18.5	17.2	31.2	7.5	1959
13	Cassava meal	86.2	1.99	3.8	77.9	1.1	2497
14	Rice bran	87.6	13	7.8	46.4	8.4	2555
15	Maize powder	90.0	10.4	1.7	71.5	2	2669
16	Peanut cake	84.5	30.1	18.1	24.0	3.3	2217

(Vietnam's National Institute of Animal Husbandry, 1995)

DETAILS OF QUESTIONAIRE

- Code
- Name of interviewer:
- Date of interviewing:
- Name of household head:
- Village:
- Commune:

1. General information of the household

1.1. **Demography information at the time of survey**

How many persons in your family:	Total:	Male:	Female:
How many labourers in your family:	Total:	Male:	Female:
How many children in your family:	Total:	Male:	Female:
How many old age persons in your family	Total:	Male:	Female:

1.2 Land and land uses at the time of survey

Total land area (Sao):…….

Total agricultural land including rented land and home garden (Sao):.....

Rented agriculture land area (Sao).....

1.3 Rate the importance of *each* income generating activity according to its income contribution to the household (3=very important, 2=moderately important, 1=less important, 0=no income of this kind)

Income generating activities	**Ranking**
Cattle production	
Other livestock production	
Crop production	
Fishing	
Government staff	
Private sector staff	
Self-employed or casual (non-farm)	
Other (please indicate)	

2. Livestock population at the time of survey

2.1. **Cattle population by genotypes, age, and sex**

2.2. **The type and number other animals**

Type of Animals	Numbers
Pig	
Chicken	
Duck and Geese	
Buffalo	
Goat	
Sheep	
Others (detail)	

3. Cow- calf production system:

3.1. **Are you interested in cow-calf production?**

Yes or No: ……..

Why ……...

3.2. **Do you want to increase the efficiency of cow-calf production?**

Yes or No:.....

Why?.....

3.3. **What is the first thing you want to change to improve your cow-calf system?**

Breed □

Feed □

Management □

Veterinary service □

Other □

3.4. **Rate the importance of *each* limiting factor for developing cow calf production (3=very important, 2=moderately important, 1=less important, 0= not important)**

Capital ☐

Feed resources ☐

Training ☐

Veterinary services ☐

Marketing ☐

Labour ☐

Other (pls indicate) ☐

4. Cow information

4.1. **The status of your cows**

	Age	Parity	Status *
Cow no.1			
Cow no.2			
Cow no.3			

* Fill the number: 1- pregnant, 2- has a calf, 3- waiting for mate; 4- others

4.2. **In the last 2 years, what was the length of:**

	Cow no.1	Cow no.2	Cow no.3
Date that it last gave birth			
Date that it previously gave birth			
Weaning dates for birth 1			
Weaning dates for birth 2			

4.3. **How do you currently inseminate cows?**

a. Natural insemination without control □
b. Natural insemination with control □
c. AI □

4.4. **If the answer is a or b, move to the next question. If using AI**

How many services to conception? ……

The price of each service: ……

4.5. **What kinds of bull genotypes do you currently use**

Yellow local □

Red Sindhi □

Crossbred Red Sindhi □

Brahman □

Crossbred Brahman □

Others:……

5. Calves information

5.1. **Calf performance**

How many kg of newborn calf: ……

How many kg of calf at weaning: ……..

5.2. **When do you usually sell your calves**

- After weaning
- Need money
- High Price
- After 12 months
- .....

5.3. **In the last 2 years, how many calves did you sell, and what was their price**

	Cow	Breed	Ages at this moment (months)	Price (VND)
Calf 1				
Calf 2				
Calf 3				

5.4. **Rate the importance of each factor affect the price of calves (3=very important, 2=moderately important, 1=less important, 0= not important)**

Breed □

Calf body condition □

Calf weight □

Market □

Abattoirs □

Others □

6. Cow-calf management

6.1. **What is the dominant cattle production system of the household?**

	Grazing	Forages	Grazing and supplementing feed at stall	Forages and supplementing feed at stall
Cow-calf				
Fattening				
Ploughing				

# of grazing hours for cow-calves in the rainy season (hours/day):.....

# of grazing hours for cow-calves in the dry season (hours/day):.....

6.2. What types of management activities do you apply

- Parasite prevention
- Bathing cattle
- Vitamin injection
- Proving water at the stall

- Providing salt
- Providing minerals
- Vaccination
- Recording time at insemination
- Early weaning
- Estimating calving time
- .....

7. Cattle feed and feeding

7.1. Indicate which feeds you use in different months of the year. What month the household faces feed shortage for cow and calf?

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Grazing common land												
Cut and carry of grass from common land												
Concentrate												
Grazing cultivated grass												
Cut and carry of cultivated forages												
Rice straw												
Other agricultural by-products (specify)												
Feed shortage												

7.2. How do you solve feed shortage for cattle?

Plant grasses □

Preserve agricultural by-products □

Buy and supplement concentrate □

Provide cut and carried grasses □

Sell calf □

Others (pls indicate) □

7.3. Rank *each* forage according to production (3=high yield, 2=moderate yield, 1=low yield)

Forage variety	Area (m^2)	Ranking based on preference	Reason *	challenges to production**

* Fill the number: 1- High yield; 2- Easy to cut and carry; 3- More leaves; 4- Cattle can eat more; 5- Easy to plant; 6- other (specify)

* *Fill the number: 1- Water; 2- Nutrient; 3- pests; 4- climate; 5-soil fertility; 6-other (specify)

7.4. Amount of food usually fed to cowsduring pregnancy

	0 – 3 months	4 – 6 months	7 -9 months
Cut and carry grass (kg)			
By-product (kg)			
Forages (kg)			
Concentrate (kg)			
Others			

7.5. Which concentrate do you use to feed your cow?

	Times/days	Amount/days (Kg)	Price (VND/Kg)
Cassava powder			
Fish meal			
Maize powder			
Foodstuff for cattle			
Rice bran			

7.6. How do you usually prepare the concentrate to feed cows?

- Mix with grass or forages
- Mix with water
- Cook
- Dry
- …….